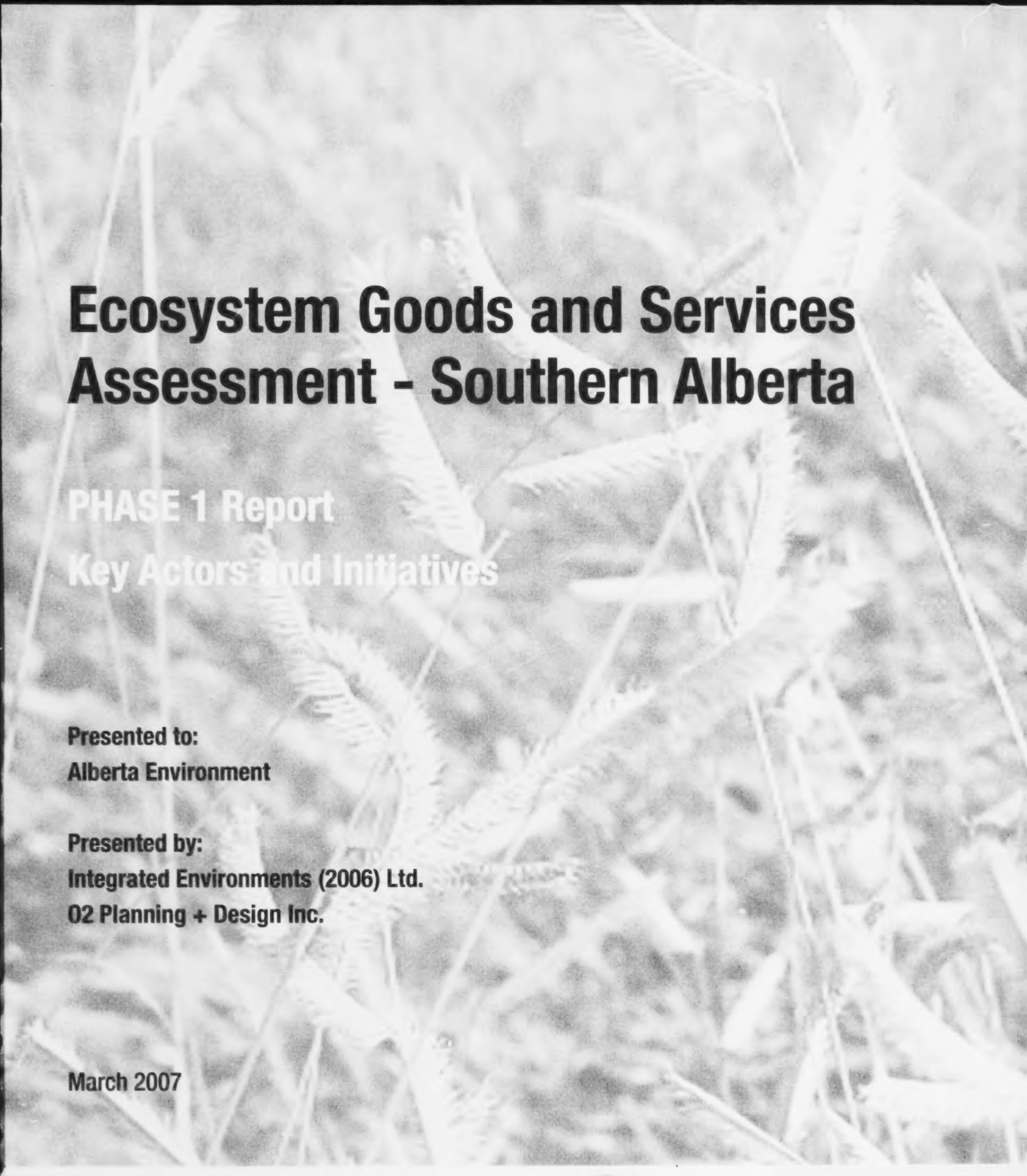

Ecosystem Goods and Services Assessment - Southern Alberta

PHASE 1 Report

Key Actors and Initiatives

Presented to:
Alberta Environment

Presented by:
Integrated Environments (2006) Ltd.
02 Planning + Design Inc.

March 2007

Alberta
Environment

Integrated Environments
Planning • Integration • Management

PLANNING O2 DESIGN
Landscape Architecture, Urban + Environmental Planning

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1. Project Background

In January 2007, Integrated Environments Limited and O2 Planning + Design Inc (IEL-O2) were retained by Alberta Environment to assess the importance of ecosystem goods and services (EGS) in southern Alberta. The EGS assessment will provide important background information in support of developing the Southern Alberta Landscapes (SAL) regional strategy and will identify areas of further investigation and study regarding the importance of EGS in southern Alberta. The geographical scope of the assessment includes the Alberta portions of the South Saskatchewan River Basin, the Grassland Natural Region, and the Cypress Hills.

The EGS assessment utilizes an adaptation of the conceptual framework and methodology created for the Ecosystems Project, "*Natural Assets*"[1]. Further, the project is divided into two phases, identification of key actors and initiatives, a literature search and gap analysis (Phase 1), and an inventory of ecosystem goods and services provided by southern Alberta landscapes and qualitative evaluation of the relative importance of the ecosystem services in southern Alberta (Phase 2).

Completion of Phase 1 is designed to identify work related to EGS that has been, or is currently being done, in southern Alberta or similar landscapes elsewhere around the globe. The identification of relevant work will lead to an expanded contact list that Alberta Environment can use to help facilitate future EGS efforts.

The Phase 1 report summarizes the responses of more than 165 organizations and individuals thought to be addressing issues important to ecosystems in southern Alberta.

In addition, Phase 1 includes an annotated bibliography of information relevant to EGS and highlights areas where information is currently lacking.

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[1] *Natural Asset: Ecosystems Project* http://www.ecosystemservicesproject.org/html/publications/docs/Natural_Assets_LR.pdf

2. Objectives

The objective of Phase 1 of the Ecosystem Goods and Services assessment is to identify key actors and EGS initiatives within southern Alberta.

Specific objectives are as follows:

1. Complete a literature search pertaining to ecosystem goods and services and develop an annotated bibliography;
2. Identify key groups and actors involved in ecosystem goods and service assessment in southern Alberta;
3. Administer a survey to document the extent of ecosystem goods and services initiatives occurring in southern Alberta and beyond;
4. Outline areas for further investigation, study and analysis; and
5. Prepare a report on the above.

3. Approach and Methods

3.1 Survey Design

The Phase 1 survey design and distribution was undertaken over a two-week period in early February in accordance with the project timeline for completion by the beginning of March 2007. In consultation with Alberta Environment, it was determined that a brief and user-friendly survey to promote a high response rate was important. As such, an Adobe Acrobat Reader based survey was delivered via email. It was felt that a primarily open-ended format would allow individual respondents an opportunity to elaborate on the work that they are involved with, or in areas where individuals possess relevant knowledge. However, the format does lend itself to a greater requirement to interpret and summarize responses and a concurrent loss of data and nominal risk of inaccuracy. Primary information garnered through the survey includes the following:

1. Contact information;
2. A determination if the respondent has, is, or would be doing work pertaining to ecosystem goods and services, or the valuation of natural capital or landscapes;
3. A description of the nature of the work, who is doing it, the geographic limits, the time frame and the methodology applied;
4. An assessment of whether the work with EGS has impacted their organization's decision-making capacity;
5. A gap analysis to identify deficiencies pertaining to EGS; and
6. Additional information sources and contacts.

The Acrobat survey was tested internally and also in conjunction with Alberta Environment to ensure both functionality and that the information being requested was optimal. The Acrobat survey form can be found in Appendix 6.1 and was accompanied by a letter of introduction provided by Alberta Environment (Appendix 6.2) and a map of the study area (Appendix 6.3).

A contact list of approximately 165 persons was generated for the survey (see Appendix 6.4). The contact list is thought to be fairly exhaustive, capturing the majority of organizations, institutions, and individuals potentially doing work on EGS, especially in southern Alberta and includes the following:

- Non-governmental organizations (NGO's);
- Rural municipalities;
- Urban municipalities;
- Universities and colleges (with primary emphasis on Alberta);
- Government of Alberta Departments;
- Government of Canada Departments; and
- Government Departments outside of Canada.

Prior to administering the email survey, contact was first established via telephone, where possible, to introduce the topic and the survey. This effort was crucial in obtaining a reasonable survey response rate among an audience widely known to be pressed for time and predisposed to similar information requests – a concern that was verified by numerous respondents who have either not responded or have required additional follow-up.

3.2 Survey Respondents

In addition to using a primarily open-ended questionnaire format, the survey was designed to be deliberately broad as to who was contacted and who was encouraged to respond. As EGS assessment is a relatively new practice with little consensus as to what this work actually involves, little initial advisement or coaching was provided to respondents. While there were a few cases where individuals followed up for clarity, and the odd case where a survey was returned, suggesting that the respondent did not understand what was being asked, overall the survey design appears to have been well received by respondents.

The following is a summary of respondent's results up to and including 8 March 2007. As of this date, a total of 65 responses were received. In general terms, the sector with the highest response rate was the various Government of Alberta departments with 10 of 15 departments, or 67% submitting at least one response.

Meanwhile, response rates from urban municipalities, post secondary institutions and federal departments and agencies lagged behind the provincial departments. This group had a response rate of approximately 25%. NGO's and rural municipalities fall between the high end provided by the provincial departments and low end of the range set by post secondary institutions and federal departments. No plausible justification is provided for the low response rates of these organizations.

Further, a number of individuals responded that while they - or the organization that they were responding on behalf of - are very much interested in conducting such work in the future, they would not be completing the survey. The common response was that they felt that it was too early to know for certain what the scope of the project and project details may be. Thus, they suggested that it would be premature to provide a response as it may lead to inaccuracies in reporting. University researchers were the group most likely to provide this comment.

As a broad note, the statistical accuracy of the results can be somewhat misleading given several factors encountered in the development of the contact list and in the way that responses have been returned. For example, there were cases where more than one individual in a given department or organization received and returned the survey. In other cases, the original recipient felt that there were one or more persons that could better answer the survey in which case multiple surveys were received. Given that the data from each respondent is somewhat different, yet equally valuable, we have elected to include all responses. The alternatives would have been to eliminate additional surveys beyond one per organization, or to combine the data into one response. Both cases would have required a subjective judgment and the potential loss of data in exchange for statistical accuracy.

Another problem with data analysis and the reporting of responses through statistical analysis is the illusion of completeness. While the following data does provide a fairly comprehensive account of individuals and organizations doing work in EGS, with emphasis on Alberta, the data is not complete. It is not known whether other individuals and organizations in addition to those who responded are in fact doing work in this area. They are not however, represented in this report nor the survey responses provided.

Tables 1 and 2 below provide an annotation of returned survey results for respondents who are, have been, or will be doing work in EGS. The tables are stratified by location with Table 1 including respondents working in southern Alberta, while Table 2 contains respondents who are working in areas outside of the region.

Table 1 – Summary of EGS Initiatives Within Southern Alberta
(Note: Projects may extend beyond southern Alberta)

Organization	Description	Date/Duration	Location	Status
Alberta Biodiversity Monitoring Program (Jim Herbers)	The ABMP is a world-class monitoring system that monitors the changing state of Alberta's diverse species, habitats, and ecosystems. Program design was lead by scientists at the UofA and the ARC, with oversight from government, industry, and environmental organizations. Information collected is summarized using state-of-the-art biodiversity indices to produce comprehensive evaluations of changes in species, habitats, and human activities.	2007-2057	Province-wide	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
Alberta Conservation Association (Velma Hudson)	Currently conducting survey work on a number of species (upland game birds, ungulates, northern leopard frogs, piping plovers,) and habitat association and assessment.	2002-2012	Province-wide	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
Alberta Environment (Gillian Kerr)	Under the Water for Life Strategy there is a cross-ministry, cross-jurisdiction (feds) project that is working on the (economic) value of water to the Alberta Economy. Using the total economic value (TEV) approach to valuation we have first established the value of water in the SSRB (Phase 1) and are currently building this up to the whole province.	March 31, 2007 Completion	Bow River Irrigation District	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
Alberta Environment (Karen Hughes-Field)	We are currently conducting an ecosystem goods and services assessment at the regional scale for southern Alberta. The project is divided into two phases, identification of key actors and initiatives, a literature search and gap analysis (Phase 1), and an inventory of ecosystem goods and services provided by southern Alberta landscapes and qualitative evaluation of the relative importance of the ecosystem services in southern Alberta (Phase 2).	Phase 1 & 2 completed by March 31, 2007	Alberta, generally south of Red Deer	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
Alberta Research Council (Craig Aumann)	This work is for the Oldman Watershed council and primarily concerned with compiling a State of the Watershed Report. This will involve 1) summarizing historic and current land use activities, water quality and water quantity, ecosystem function, and biodiversity information; 2) establishing links between land use and watershed health; 3) identify gaps hindering management in the OWC.	December 1, 2007	Oldman River Watershed	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing

Table 1 Cont'd – Summary of EGS Initiatives Within Southern Alberta

(Note: Projects may extend beyond southern Alberta)

Organization	Description	Date/Duration	Location	Status
Alberta Research Council (Marian Weber)	1. Northern Ecosystem Initiative Working Landscapes Project - Socio-Economic Component - socio-economic evaluation of thresholds for land use change using integrated tools 2. Watershed Evaluation of Beneficial Management Practices - Farm Behavior Component - exploring adoption rates and costs of agricultural BMPs under alternative policy scenarios 3. Incentive Policies for Sustainable Forest Management - exploring economic instruments for conserving natural capital in the boreal forest 4. Beaver Hills Initiative - Exploring incentives for protecting natural capital in the BHI 5. Alberta Government EGS Feasibility Study (2004) - exploring feasibility of using market based approaches for enhancing EGS on agricultural lands 6. Value of Nat. Capital - Water study Ph. 1 with Gardner Pinfold	1. 2004-2008 2. 2006-2008 3. 2005-2008 4. 2006-2007 5. 2004-2005 6. 2005-2006	1. Yukon & NWT 2. Manitoba and Quebec 3. Northern Alberta 4. BHI Management Area 5. Alberta 6. SSRB	☒ Planning ☒ In progress ☒ Complete ☐ Ongoing
Alberta Science and Research Authority (Rick Nelson)	Determination of the value of water in the South Saskatchewan River Basin.	(Phase 1 & 2 complete, phase 3 approx 6 months more)	South Saskatchewan River Basin	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
Alberta Sus. Res. Dev. (SRD), Rangeland Management (Michael Willoughby)	Plant community guides, ecosystem health (rangeland and riparian), long-term ecological monitoring.		Province-wide	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
Alberta Sus. Res. Dev. (SRD), Fish and Wildlife (Mike Sullivan)	Creel surveys to estimate angler days at lakes and streams which is then translated into financial data.	Annually since 1940's	Province-wide	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing

Table 1 Cont'd – Summary of EGS Initiatives Within Southern Alberta
(Note: Projects may extend beyond southern Alberta)

Organization	Description	Date/Duration	Location	Status
Canada West Foundation (Geneva Rae)	Core objective is to explore public policy options for improving management of natural capital in western Canada. Project aims to increase understanding of the economic value of natural capital, growth management challenges in AB and land stewardship across the four Western provinces. Research is exploring the question of how public policy can facilitate land stewardship. The current research report is attempting to identify how valuation of EGS can be integrated into agriculture policy.	Ag. Report - fall 2007; Land Stewardship Initiative - concludes August 31, 2008	Alberta - Pekisko/ Livingstone range. A location for a case study in BC has not been identified.	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
Canadian Cattleman's Association (Joyce Greenfield)	Proposed study is entitled "Environmental Goods and Services Market Development for the Canadian Beef Sector".	2 year study	Canada-wide	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing
Canadian Parks and Wilderness Association (Dave Poulton)	In the coming year CPAWS is planning to publish an evaluation of the social, economic and ecological benefits of Canada's park system (federal and provincial).	May 2008 Completion	Canada-wide	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing
Central Rockies Ecosystem Interagency Liaison Group (Ray Andrews)	Update the atlas of Central Rockies Ecosystem.	2 years	Canadian Central Rockies	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
City of Lethbridge (Kevin Jensen)	Comprehensive inventory of the City's urban forest.	1-2 years	City of Lethbridge	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
City of Red Deer (Grant Moir)	Development of an Ecological Management System that will be used to value natural capital.	Many years	City of Red Deer and area	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing

Table 1 Cont'd – Summary of EGS Initiatives Within Southern Alberta
(Note: Projects may extend beyond southern Alberta)

Organization	Description	Date/Duration	Location	Status
Cottonwood Consultants Ltd. (Cliff Wallis)	Several inventories of species at risk.	Ongoing	Scattered locations across southern region	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
Cows and Fish (Michael Gerrand)	Riparian health inventories and assessments on a watershed scale.	Since 1998	Province-wide	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
Ducks Unlimited (Cynthia Edwards)	1. As part of a conservation easement pilot project, surveyed landowners regarding their willingness to place a conservation easement on their property. 2. As part of our tax credit pilot project in SK, a time-series survey was done of landowners in and adjacent to, the pilot areas. 3. As part of a tax credit pilot done in MB (which DUC was a partner on) a graduate thesis was completed that contained interviews of landowner and survey	1. Pilot was about a year - survey was done once - 2002/03 2. Time series surveys '03-05 3. Project and evaluation done '99-01	1. 4 CE pilot sites in Cdn. Prairies - 1 in AB, 2 in SK, 1 in MB 2. 2 pilot rural municipalities in SK 3. RM in Manitoba	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
Elbow River Watershed Partnership (Sarah Hamza)	Planning to do a number of riparian health inventories along the Elbow River.	Summer 2007	Elbow River	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing

Table 1 Cont'd – Summary of EGS Initiatives Within Southern Alberta

(Note: Projects may extend beyond southern Alberta)

Organization	Description	Date/Duration	Location	Status
International Institute for Sustainable Development (IISD) (Hank Venema)	1. "Linking IWRM to Payments for Ecosystem Services" in the prairies with a section on international best practices. 2. Potential for payments for ecosystem services from an institutional perspective in the context of the Lake Winnipeg watershed. 3. Natural Capital Approach - IISD, funded by Environment Canada, is undertaking research into the conceptual underpinnings of the Natural Capital Approach in order to devise a suitable framework for its application within the Red River Basin of Southern Manitoba. 4. Commercial Client – IISD has evaluated the ecosystem service values and ecosystem service offset trading potential for a client-owned site located in Western Canada.	1. Expected to be completed by July. 2. expected to be completed by July 3. 2 to 3 years 4. Completed- will not be released	1. Lit. and case review in the international context 2. Int'l best practice section, rec's applicable to Lake Winnipeg watershed 3. Red River Basin, s.MB 4. Urban centre - Western Can.	☐ Planning ☒ In progress ☒ Complete ☐ Ongoing
Lethbridge Community College (Terry Kowalchuk)	Developing an Environmental Management Plan for the College which will calculate an ecological footprint.	5 years	City of Lethbridge	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing
Lethbridge Naturalists Society (Graeme Greenlee)	Walk-a-park initiative - members make notes and take pictures on the condition of various city parks; and visual inspection/assessment of current conditions.		City of Lethbridge and Police Outpost Wetlands	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
M.D. of Rockyview / The Nose Creek Watershed Partnership (Sheik Ahmed)	1) Contributor to Alberta's Water for Life strategy. 2) Working with AENV on a Wetland Inventory. 3) A ground water/ aquifer study, project has been planned as a step to develop detailed Ground water policy for the MD.			☐ Planning ☐ In progress ☐ Complete ☒ Ongoing

Table 1 Cont'd – Summary of EGS Initiatives Within Southern Alberta
(Note: Projects may extend beyond southern Alberta)

Organization	Description	Date/Duration	Location	Status
Milk River Watershed Council Canada (Sandi Riemersma)	Defining watershed indicators to develop the Milk River State of the Watershed Report. There will be a certain valuation to the indicators; however this is not well defined at this time.	2007	Milk River Watershed	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing
Oldman Watershed Council (Stephanie Palecheck)	Contributor to Water for Life strategy.	July 2006 – March 2007	Province-wide	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
Parks Canada, Banff National Park (Ian Syme)	Economic impact of National Parks. Visitor patterns of use studies.	1998 and 2003	Alberta National Parks	☐ Planning ☐ In progress ☒ Complete ☐ Ongoing
Pembina Institute for Appropriate Development (Amy Taylor)	Past initiatives: 1. Alberta Genuine Progress Indicator 2. Counting Canada's Natural Capital Current: 3. Contract for Ontario Ministry of Natural Resources - It is a survey of valuation and pricing policies in 6 jurisdictions around the world.	3. Complete by June 2007	1. Alberta 2. Boreal forest. 3. Jurisdictions have not been chosen yet.	☐ Planning ☒ In progress ☒ Complete ☐ Ongoing
Prairie Conservation Forum (Brian Laing)	Assessment of ecosystem goods and services attributable to prairie landscapes with emphasis on native rangelands but will also assess modified prairie for comparative purposes.	2 phases, 1st phase 2008, 2nd 2011	South with emphasis on Milk River Ridge	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing

Table 1 Cont'd – Summary of EGS Initiatives Within Southern Alberta

(Note: Projects may extend beyond southern Alberta)

Organization	**Description**	**Date/Duration**	**Location**	**Status**
Prairie Farm Rehabilitation Administration (Mark Wonneck)	1. Supporting the ALUS project in Manitoba. This is a pilot project within a rural municipality to evaluate the feasibility of providing payments to farmers for environmentally-friendly practices. Part of the study includes an evaluation of the impact of the program on the provision of EGS from these landscapes. 2. Under the ACAAF program, have received many applications for pilot projects to test the feasibility of PES schemes. 3. Are involved with the Prairie-Parkland EGS Valuation Study which is planning to develop and pilot ways of valuing EGS in two landscapes in the prairie and parkland regions of Alberta. 4. The agroforestry division is developing a model to describe the environmental values of agroforestry. The model will necessarily describe the ecological functions of trees in agricultural landscapes, and the necessary pre-conditions for these functions.	1. Manitoba 2. New projects -- distributed throughout the ag regions of Canada. 3. PPEGSVS -- southern Alberta 4. EVA study -- prairie region	1. 3 years (to be complete march 2008 2. New projects -- TBD 3. PPEGSVS -- 2 years (complete in march 2009 4. EVA -- 1 year (to be completed)	☒ Planning ☒ In progress ☐ Complete ☐ Ongoing
Red Deer County (Harry Harker & Johan van der Bank)	Sensitive ecosystem inventory. Wetlands and riparian areas policy and management plan.	9-15 months	Red Deer County	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing
Red Deer River Naturalists (Bill Heinsen)	Bird, plant, and invasive plant inventories.		Red Deer River Watershed	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
Red Deer River Watershed Alliance (Beverly Anderson)	The Red Deer River Watershed Alliance as the WPAC for the Red Deer River is required to do both a State of the Watershed (SOW) report and a Watershed Management Plan.	SOW - approx. 2 years. WMP approx. 1 year to complete.	Red Deer River Watershed.	☒ Planning ☐ In progress ☐ Complete ☐ Ongoing
Southern Alberta Land Trust Society (Alan Gardner)	The Southern Foothills Study (SFS) looks at the cumulative effect of all land uses on the landscape within the study area.	Began 2005	Southwest Alberta	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing

Table 1 Cont'd – Summary of EGS Initiatives Within Southern Alberta
(Note: Projects may extend beyond southern Alberta)

Organization	Description	Date/Duration	Location	Status
Sweetgrass Consultants Ltd. (Cleve Wershler)	Inventory of species at risk and wetlands in the Grassland Natural Region.	Ongoing	Scattered locations across southern region	☐ Planning ☐ In progress ☐ Complete ☒ Ongoing
University of Calgary (Carla Stevens)	Master's Degree Project title: Ecological Infrastructure: An approach for managing infrastructure investment in rural municipalities. Purpose is to develop a methodology for assessing the spatial pattern and processes of natural features within a small agricultural watershed experiencing land use change pressures, specifically conversion to country residential development.	2005-2007	Red Deer County, western portion of the Sylvan Lake watershed	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
University of Calgary (Shana Sundstrom)	An assessment of the cross-scalar functional diversity of the mammals and birds of the dry mixed grassland in southeastern Alberta.	2006-2007	The dry mixed grassland subregion of SE Alberta	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
Western Sky Land Trust (Tracy Tarves)	Land conservation focused on conservation of watershed lands associated with agricultural, natural, heritage, scenic and recreational values.	No time frame determined	Principally Calgary and the MD's of Foothills and Rockyview	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
Wildlife Habitat Canada (Lynn McIntyre)	A national survey of ecological goods and services of farmers and ranchers in Canada.	1 year	Canada-wide	☐ Planning ☐ In progress ☒ Complete ☐ Ongoing

Table 2 – Summary of EGS Initiatives Outside Southern Alberta

Organization	Description	Date or Duration	Location	Status
Anielski Management Inc. (Mark Anielski)	Two studies conducted for the Canadian Boreal Initiative. 1. "Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystem" was a two year study to develop a natural capital account of the natural capital assets and ecosystem goods and services (physical inventory and full economic valuation) of the Boreal ecosystem of Canada. 2. The Real Wealth of the Mackenzie Region of the natural capital conditions and ecosystem goods and services of the Mackenzie region/watershed.	1. 2003 - 2005. 2. Approx. one month to complete.	1. Canadian boreal ecosystem 2. Mackenzie watershed	☐ Planning ☐ In progress ☒ Complete ☐ Ongoing
Aquality Environmental Consulting (Jay White)	Wetlands valuation study for Lakeland County. Quantifying the value of water polishing prior to discharge into Lac la Biche.		Lakeland County	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
City of Edmonton	The City of Edmonton is currently collecting the tree inventory electronically. The City has never had a complete inventory of the trees it maintains. All ornamental trees as well as areas of natural stands will be inventoried.	2005 - 2009	City of Edmonton	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing
Millennium Ecosystem Assessment (Ciara Raudsepp-Hearne)	Living beyond our means: Natural assets and human well-being Ciara is a researcher at McGill working with the WRI to develop a handbook on ecosystem service assessment and is studying ecosystem services in southern Quebec to develop methods to look at 'bundles' of ecosystem services on a landscape, as opposed to studying individual ecosystem services.	2005	International Province-wide	☐ Planning ☒ In progress ☒ Complete ☐ Ongoing
Simon Fraser University (Nancy Olewiler)	Nancy has written a number of papers on EGS. With our Masters in Public Policy students have undertaken some surveys to value EGS (e.g., for Lac La Biche/Lakeland County, AB for Fraser Valley, BC).		Lac la Biche Fraser Valley, and possibly Ontario	☒ Planning ☐ In progress ☒ Complete ☐ Ongoing
World Resources Institute (Janet Ranganathan)	Developing, road testing and publishing a corporate ecosystem services methodology.	Publication of methodology in 2008	British Columbia, Guinea, South Africa, India	☐ Planning ☒ In progress ☐ Complete ☐ Ongoing

4. Ecosystem Goods and Services Survey Results

Note: The following data represents survey responses up to 8 March 2007.

4.1 Survey Response

Total number of contacts identified and surveys distributed:	165
Total number of surveys returned from contact list:	65
Overall response rate:	41 %

Actual responses are included in a separate electronic data file in a MS Excel worksheet. Hard copies accompany this report. Survey information that is collected after 8 March (although not contributing to this document) will be submitted to AENV as it becomes available.

4.2 Who is Doing What?

Respondents were asked to answer "Yes, we have done", "Yes, we are doing", "Yes, we plan to", or "No" when asked the question "Have you done, are doing, or plan to do any studies or surveys relating to ecosystem goods and services or the valuation of natural capital or landscapes?" The responses are as follows, where n is the total (n=65):

Total		% of response
16	Yes, we have done	24 %
18	Yes, we are doing	28 %
11	Yes, we plan to	17 %
20	No	31 %
65	**Total**	100%

When asked if they have done, are doing, or plan to do any studies or surveys relating to ecosystem goods and services, or the valuation of natural capital or landscapes, 70 percent of respondents answered "Yes" to this question. This high percentage of "Yes" responses is surprising at first look, and in fact is a little misleading, depending upon the respondent's interpretation of ecosystem goods and services assessment. IEL-O2 took a deliberately broad approach to the survey design to ensure as many possible practitioners could be captured in the survey. It is easier to eliminate extraneous data gathered through the survey than it is to extrapolate results where data was not acquired. Therefore, the data in Tables 1 and 2, that comprise the 70 percent response, include initiatives that may have little or no relevance to EGS assessment. Certainly the initiatives could be placed on a continuum of low to high relevance to the EGS assessment. For example, at the low end would be simple visual inspections and surveys such as those conducted by the Lethbridge and Red Deer River Naturalist Societies. In contrast, initiatives being undertaken by the Prairie Conservation Forum and Wildlife Habitat Canada and others are much larger in terms of scale and much more advanced. These initiatives are highly relevant to the EGS work.

Another concern with the data in terms of accuracy and the likely overstatement of groups undertaking EGS work arises from the survey methodology. To ensure that as many organizations undertaking this work can be accounted for as is possible, IEL-02 was more selective in the follow-up efforts with contacts. That is to say that individuals and organizations which were believed to be most likely to be working on EGS initiatives were given priority in follow-up efforts.

A second survey question to ascertain "Who is doing what?" was incorporated into the survey. The following is a breakdown of who is undertaking the work with respect to ecosystem goods and services and/or valuation. Note that one project may include more than one organization (e.g. government may team up with a contractor or university to undertake a project). The total includes multiple actors undertaking the same EGS initiative.

Total		% of response
14	Government (federal, provincial, or municipal)	31 %
13	Private contractor for government	29 %
5	University / Research institute for government	11 %
14	Non-governmental organization (NGO)	31 %
6	Private contractor for NGO	13 %
3	University / Research institute for NGO	7 %
5	University / Research institute	11 %

4.3 Where is the Work Being Done?

To get at where the work is being undertaken, the question was asked: "Where is the initiative located, and what are the geographic boundaries?" The following is a summary of responses provided for the 45 initiatives that have been undertaken, are being undertaken, or are in the planning stages.

Total		% of response
23	Southern Alberta	51 %
10	Elsewhere in Alberta or province wide (may include southern Alberta)	22 %
12	Outside Alberta, Canada wide or international (may include southern Alberta)	27 %
45	**Total**	100%

4.4 What is the Nature of the Work?

Given that EGS assessment is multi-faceted, we were particularly interested in learning what specific areas of EGS respondents are working. The following is a summary of the work being done from basic inventory through to economic valuation of natural assets. (n=45).

Total		% of response
34	Inventory	**76 %**
40	Assessment of status quo	**89 %**
30	Assessment of threats	**67 %**
26	Economic valuation	**58 %**
11	Other	**24 %**

The number of respondents noting that they are, or will be actively involved in the economic valuation of natural assets is surprising (58 %). Further analysis and follow up may be necessary to determine the extent to which this is true.

4.5 Preliminary Gap Analysis

Survey respondents were also asked what additional investigation of ecosystem goods and services in Alberta is required. These responses will be used to assist us in providing a gap analysis of where future efforts should be expended in this regard. The responses will be analyzed and synthesized as part of the EGS gap analysis that will be delivered as part of the Phase 2 report.

More than one respondent provided the following remarks:

- Incentive programs for landowners to maintain or enhance ecosystems;
- More primary research on EGS (one respondent noted, especially where oilsands development occurs);
- Full cost accounting, including cost of providing community services;
- Need to link EGS to urban areas and determine willingness-to-pay for such services;
- Full life cycle planning;
- The need to ensure that the private sector becomes involved in EGS;
- Need to design science and communication tools that decision-makers desire;
- Assessment of the cumulative effects & thresholds relating to development;
- Coordinated efforts among the various agencies working in this area; and
- Standardized valuation methods/framework should be produced.

One respondent made the following remarks:

- Need to provide for consultation to our greatest natural capital (humans) – focus groups;
- Address approaches to conducting consultation at different geographic scales;
- Comprehensive study of the value of ecological components at a watershed level including valuation of healthy systems;
- Understanding of the impacts of subsidies;
- Additional work of a similar nature by someone with authority;
- Watershed scale plans should be created to direct municipalities;
- Need to incorporate "indicators" into work being done in this area;
- Development of tools that can be used to protect natural capital (e.g. transferable development credits);
- Production of a compendium of studies and techniques completed;
- Understanding of the social values of agriculture in terms of land ownership;
- Legal issues pertaining to the valuation of EGS;
- Study credits for biodiversity, CO_2 sequestration, water, and sustainable timber as examples;
- Recognition of the importance of context – no one size fits all solution;
- Need to understand the "flow of benefits" from southern AB landscapes;
- Need to determine the current status and condition of ecosystem services in southern AB;
- Need to study the interdependence between ecosystem services;
- Need to examine to what extent and over what time scales are ecosystem services restorable;
- Need to examine the relationship between industrial development and the marginal cost to ecosystem service functions and their full economic value;
- More economic valuation analysis of incomplete areas of ecosystem service functions;

- Monitoring of human use as it relates to increased presence on the natural landscape and ecosystem sustainability;
- Pilot studies for auction-based systems for EGS;
- Cost benefit analyses of use of economic instruments for resource management (such as watershed management) vs. traditional methods of resources for infrastructural development;
- Government pilot programs for payments for ecosystem services (PES) in resource management, watershed management and to help build Comm. based natural resource management capacity;
- PES in local communities and in centralized systems (provincial and national);
- Material flow analysis and energy analyses; and
- Need to move from study to implementation – i.e. what policy tools can we implement to start incorporating better pricing signals into the market.

5. Annotated Bibliography

An annotated bibliography of information relevant to ecosystem goods and services is presented as part of the efforts to provide critical reference material necessary to underpin the overall success of this assessment.

Initially, it was thought that the work and publications in this field would be fairly limited. As it turns out, ecosystem goods and services assessment contains a large body of work. This is especially true in the theoretical realm and due to a limited number of academics publishing in this field. There is however, material from practitioners present as well.

This reality suggests that the valuation of natural assets is perhaps not as new as many would believe, and perhaps its novelty in recent years through the mass media aids in this misperception. In fact, with his 1969 article published in just the third volume of the peer-reviewed *Regional Studies*, D.R. Helliwell provides the earliest reference in our bibliography. In this work, Heliwell notes that the recognizable benefits afforded by wildlife include production, potential production, education, and recreation. As conventional cost-benefit analysis is regarded as both too tedious and too difficult a process to be widely and frequently used, an attempt is made to provide a system for comparing wildlife resources; with the whole system being correlated to monetary values at a later stage.

Walter Westman provides another significant and early reference in this bibliography with his 1977 article published in *Science*. The article is entitled "How Much Are Nature's Services Worth? Measuring the social benefits of ecosystem functioning is both controversial and illuminating". Now some 30 years later, the worth of nature is an emerging study area with an abundance of interconnected fields. These are just two early examples of work in the area of EGS.

The literature search was Internet based and utilized the University of Calgary's Online Library catalogue, Amazon bookstore, Google Canada and Google Booksearch in addition to various websites pertaining to EGS. Academic peer-reviewed journal articles were accessed through the University of Calgary Libraries restricted access E-Journals section.

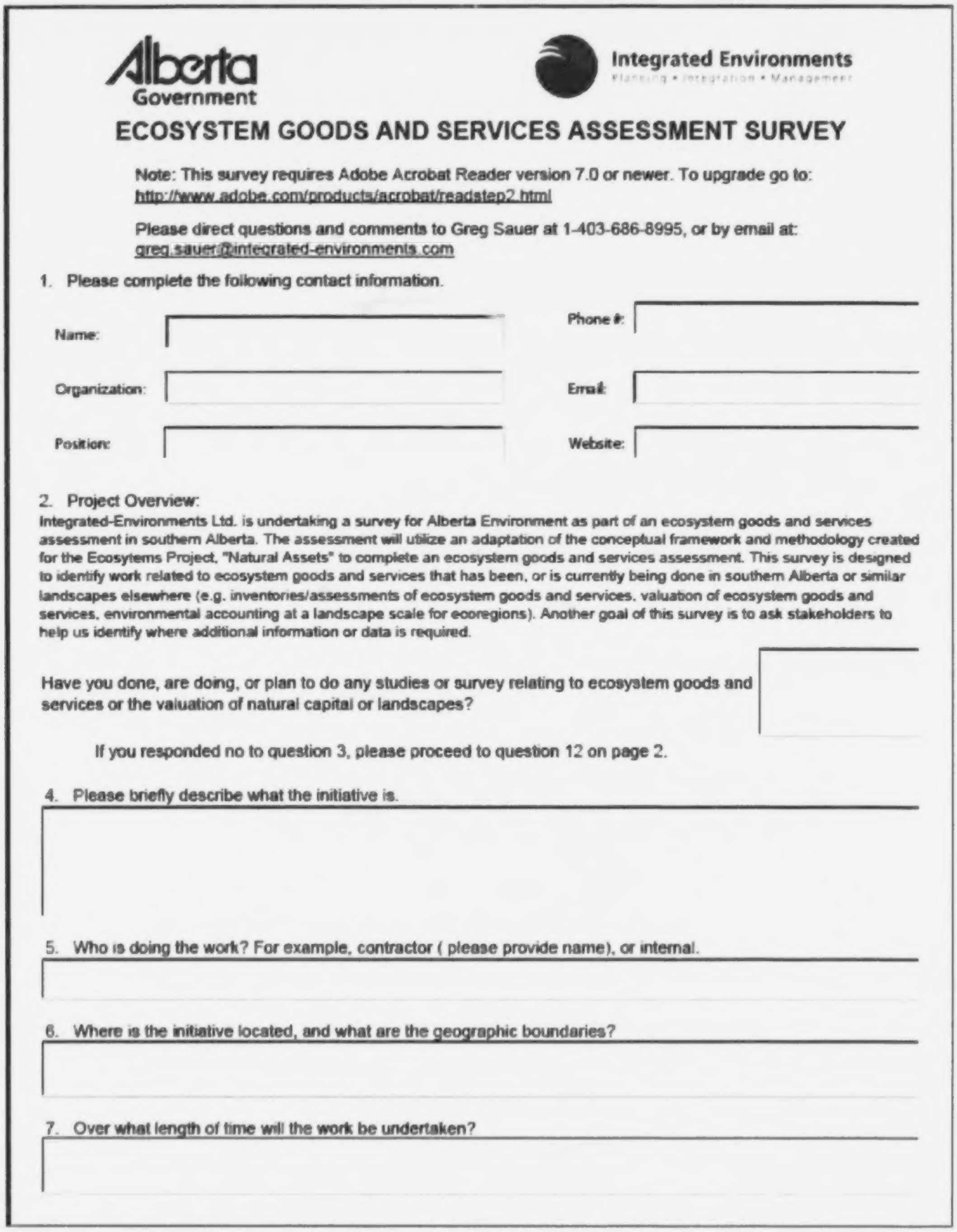
To date the annotated bibliography contains 206 references to EGS related work. It should however be noted that this database contains documents with varying levels of applicability to the EGS assessment. As a result, it will be up to each reader to determine if the work is of value to their area of interest. Further, the database includes both peer-reviewed articles and books, but also "grey literature" which includes various government and non-government reports that have not received peer-review.

The 206 references that have been retrieved to date should also be viewed as an incomplete product as certainly there are more documents available that are not yet contained in the database. Efforts to update the contents of this bibliography would be useful as this initiative will be ongoing.

The annotated bibliography is attached as Appendix 6.5 and has been generated using Endnote© software. Endnote allows the reader to create an easily modified reference list that can generate a significant number of varying outputs. For the purposes of this interim report, the annotated bibliography is sorted alphabetically by lead author.

6. Appendices

6.1 Sample Survey Form



Alberta Government

Integrated Environments
Planning • Integration • Management

ECOSYSTEM GOODS AND SERVICES ASSESSMENT SURVEY

Note: This survey requires Adobe Acrobat Reader version 7.0 or newer. To upgrade go to: http://www.adobe.com/products/acrobat/readstep2.html

Please direct questions and comments to Greg Sauer at 1-403-686-8995, or by email at: greg.sauer@integrated-environments.com

1. Please complete the following contact information.

Name:
Phone #:
Organization:
Email:
Position:
Website:

2. Project Overview:

Integrated-Environments Ltd. is undertaking a survey for Alberta Environment as part of an ecosystem goods and services assessment in southern Alberta. The assessment will utilize an adaptation of the conceptual framework and methodology created for the Ecosytems Project, "Natural Assets" to complete an ecosystem goods and services assessment. This survey is designed to identify work related to ecosystem goods and services that has been, or is currently being done in southern Alberta or similar landscapes elsewhere (e.g. inventories/assessments of ecosystem goods and services, valuation of ecosystem goods and services, environmental accounting at a landscape scale for ecoregions). Another goal of this survey is to ask stakeholders to help us identify where additional information or data is required.

Have you done, are doing, or plan to do any studies or survey relating to ecosystem goods and services or the valuation of natural capital or landscapes?

If you responded no to question 3, please proceed to question 12 on page 2.

4. Please briefly describe what the initiative is.

5. Who is doing the work? For example, contractor (please provide name), or internal.

6. Where is the initiative located, and what are the geographic boundaries?

7. Over what length of time will the work be undertaken?

8. What methodology was used, or will be used on this project?

9. Does the work include any of the following? Please explain.

☐ Inventory

☐ Assessment of current conditions and status

☐ Assessment of threats

☐ Economic Valuation

☐ Other

10. Do you include the consideration of ecosystem goods and services, or the valuation of natural capital and landscapes in your land-use planning or resource allocation decisions?

If yes, can you explain briefly how this is done?

11. Are there any publications on the work, if so where?

12. Do you have any suggestions as to what type of additional study should be undertaken in this regard?

13. Are you aware of anyone else that we should contact? Please provide name and contact details.

Integrated Environments Ltd. and Alberta Environment appreciate your considered responses to the above questions. Thank you very much, and have a great day!

Submit by Email

6.2 Letter of Introduction

Alberta Environment

Manager, Environmental Information
Southern Region, Alberta Environment
200-5th St. South Lethbridge, AB, T1J 4L1
(Provincial Building).

Telephone: 403-382-4106
Fax: 403-381-5969
Web: www.environment.gov.ab.ca

To whom it may concern

Alberta Environment has contracted with Integrated Environments to undertake a survey as part of an ecosystem goods and services assessment. This assessment will include the identification and qualitative evaluation of the full range of ecosystem services in southern Alberta.

This initiative will be a strategic assessment that will be useful for background information in the development of regional strategies. In addition we hope this assessment will lay the foundation for further focused work in this emerging field of analysis. We anticipate that it will help us to understand the value of high quality ecosystems in relation to economic production in southern Alberta, and the possible consequences of land use decisions i.e. the relative impact of human activities on the supply of ecosystem services. We will attempt to highlight the relationship between the condition of an ecosystem (e.g. relatively pristine versus heavily modified) and the quantity and quality of ecosystem services it supplies. Finally we will also strive to set the required context for regional strategies to determine or recommend what portion and/or spatial pattern of landscapes would be needed in order to sustain the delivery of ecosystem goods and services.

The ecosystem goods and services assessment is as a phased project, in which the survey you are being requested to partake in will be used to lay the foundation for further work. We would greatly appreciate your cooperation and involvement in this endeavor and would be pleased to share the results upon its completion. If you have any concerns or questions, please do not hesitate to call me directly at 403-382-4106.

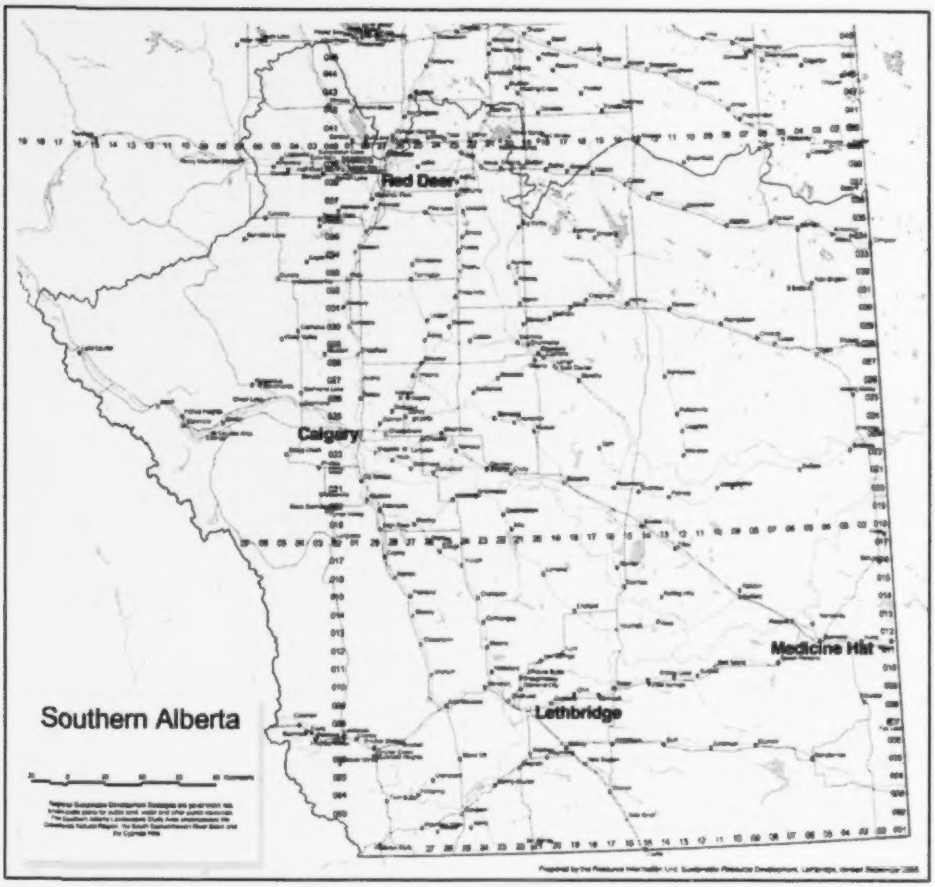
Sincerely

Lana Robinson

Manager, Environmental Information

cc: Karen Hughes-Field

6.3 Map of Southern Alberta



6.4 List of Organizations Surveyed

Table 1. Non governmental organizations (NGO's)
Organization
Action for Agriculture
Agricultural Producers Association of Saskatchewan
Agriculture Institute of Canada - Prairie Habitat Joint Venture
Alberta Biodiversity Monitoring Program
Alberta Chamber of Resources
Alberta Conservation Association
Alberta Ecotrust Foundation
Alberta Environmentally Sustainable Agriculture
Alberta Fish and Game Association
Alberta Ingenuity Center for Water Research
Alberta Irrigation Projects Association
Alberta Native Plant Council
Alberta Urban Municipalities Association
Alberta Water Council
Alberta Wilderness Association
Anielski Management Inc.
Aquality Consulting
Beaver Hills Initiative
Bow River Basin Council
Bow Riverkeeper
Canada West Foundation
Canadian Boreal Initiative
Canadian Cattleman's Association
Canadian Nature Federation
Canadian Parks and Wilderness Society
Canadian Society for Ecological Economics
Canadian Water Network
Canadian Water Resources Association
Canadian Wildlife Federation
Canadian Wind Energy Association
Castle-Crown Wilderness Coalition
Cottonwood Consultants Ltd
Cows and Fish Project
The David & Lucile Packard Foundation
Ducks Unlimited Canada
Eastern Irrigation District
Elbow River Watershed Partnership
Federation of Alberta Naturalists
Federation of Canadian Municipalities
Forem Technologies
The Grasslands Conservation Council of British Columbia

Table 1 Cont'd. Non governmental organizations (NGO's)
Organization
Imagine Calgary
International Institute for Sustainable Development
Land Stewardship Centre of Canada
Lethbridge Naturalist Society
Miistakis Institute for the Canadian Rockies
Milk River Watershed Council
Millennium Ecosystem Assessment
Nature Conservancy of Canada
North Saskatchewan Watershed Alliance
The Nose Creek Watershed Partnership
Oldman River Regional Services Commission
Oldman Watershed Council
Parkland Community Planning Services
The Parkland Institute
Pembina Institute (Boreal report)
Prairie Conservation Forum
Red Deer River Naturalists
Red Deer River Watershed Alliance
River Watch
Sandy Cross Conservation Foundation
Shell Canada Ltd.
Sierra Club of Canada
Society of Grasslands Naturalists
Southern Alberta Land Trust Society
St. Mary's River Irrigation District
Spray Lakes Sawmill
Sustainable Forest Management Network
Sweetgrass Consultants Ltd.
Treaty 7 Management Corporation
Tree Canada Foundation
Trout Unlimited Canada
United Farmers of Alberta
Urban Land Institute
Water for Life Coordinator
Weaselhead Glenmore Preservation Society
Western Irrigation District
Western Sky Land Trust
Wildlife Habitat Canada
Wildlife Society
Woodlot Association of Alberta
Woods Institute for the Environment
World Conservation Monitoring Centre (Cambridge, England)
World Resources Institute
World Wildlife Fund Canada

Table 2. Municipal Districts

Municipality
Municipal District of Bighorn No. 8
Municipal District of Foothills No. 31
Lacombe County
Red Deer County
Municipal District of Rocky View No. 44
Special Areas Board

Table 3. Urban Municipalities

City /Town	
City of Brooks	Parks
City of Calgary	Parks
	Environmental
City of Edmonton	Parks
	Environmental
City of Lethbridge	Parks
	Environmental
	Asset Management
City of Medicine Hat	Parks
	Environmental
City of Red Deer	Parks Ecological Services

Table 4. Government of Alberta Departments
Department / Agency
Alberta Agriculture, Food and Rural Development
Alberta Biodiversity Monitoring Program
Alberta Community Development, Parks and Protected Areas
Alberta Community Development, Alberta Sport, Recreation, Parks and Wildlife Foundation
Alberta Economic Development
Alberta Energy (Mineral Resources Branch)
Alberta Energy and Utilities Board
Alberta Environment, Southern Alberta Landscape Strategy
Alberta Infrastructure and Transportation
Alberta Municipal Affairs
Alberta Sustainable Resource Development
Alberta Research Council
Alberta Science and Research Authority
Natural Resources Conservation Board
Alberta Tourism, Parks, Recreation and Culture

Table 5. Canadian Universities & Colleges
Name
Keyano College
Lethbridge College
Medicine Hat College
Mount Royal College
Olds College
Red Deer College
Simon Fraser University
University of Alberta
University of British Columbia
University of Calgary
University of Lethbridge
University of Regina
University of Saskatchewan

Table 6. Government of Canada
Department / Agency
Agriculture and Agri-Food Canada
Central Rockies Ecosystem Interagency Liaison Group
Department of National Defence, Canadian Forces Base - Suffield
Environment Canada, Canadian Wildlife Service
Env Canada – North American WaterFowl Management Plan Coordination Office
National Water Research Institute
National Energy Board
National Round Table on the Environment and the Economy
Parks Canada, Banff Park
Parks Canada, Waterton Park
Prairie Farm Rehabilitation Administration

Table 7. Other Research Networks Not Contacted
Association of Environmental and Resource Economists About the AERE: Founded in 1979, the Association of Environmental and Resource Economists (AERE) was established as a means of exchanging ideas, stimulating research, and promoting graduate training in resource and environmental economics.
CSIRO Sustainable Ecosystems - a research organisation and business unit of CSIRO About CSIRO Sustainable Ecosystems: CSIRO Sustainable Ecosystems is focused on maintaining the sustainability of Australia's landscapes, environments and communities.
The Centre for Social and Economic Research on the Global Environment (CSERGE) About the CSERGE: CSERGE consists of a number of collaborating disciplines including economics, political science, geography, information systems and the natural sciences.
Ecosystem Services Project About the Ecosystem Services Project: The Ecosystem Services Project is a collaborative natural resource management project studying the services people obtain from their environments, the economic and social values inherent in these services and the opportunities that can arise from considering these services more fully in land management policies and decisions.
Ecosystem Valuation About Ecosystem Valuation: This website describes how economists value the beneficial ways that ecosystems affect people – ecosystem valuation. It is designed for non-economists who need answers to questions about the benefits of ecosystem conservation, preservation or restoration.
Foundation for Sustainable Development – Ecosystem Assessment & Nature Valuation About the FSD: The Foundation for Sustainable Development is active in carrying out targeted valuation studies and developing valuation frameworks and tools to facilitate balanced assessments of the real 'value' of specific ecosystems (functions and services), biogeographical areas or delineated regions.
Gund Institute for Ecological Economics (Uni. Of Vermont) About the Gund Institute: Developing, testing, and implementing innovative methods and models that reflect the need to integrate the social, built, natural, and human capital components of our world.
Laboratorio di Valutazione Ambientale (ENVALAB) About ENVLAB: ENVALAB undertakes high quality studies and research on the economic valuation of non-market goods, especially environmental resources and cultural heritage, and on other important topics of the environmental and natural resource economics.

Table 7 Cont'd. Other Research Networks Not Contacted
IUCN – The World Conservation Union - Commission on Ecosystem Management (CEM) About the IUCN - CEM: The Commission on Ecosystem Management is one of IUCN's six scientific Commissions. CEM is a network of about 500 volunteer ecosystem management experts from around the world. CEM and its individual members are involved in a wide range of Ecosystem Management activities. CEM is supported by the Ecosystem Management Programme and its Secretariat both located at the IUCN Headquarters in Gland, Switzerland.
Nature Valuation and Financing Network About the NV&F: The aim of the Network (NV&F) is to stimulate the development and exchange of practical tools and best practice for the valuation of ecosystem goods and services, so that decisions concerning economic development are made with full awareness and understanding of all the costs and benefits involved.

6.5 Annotated Bibliography

Acharya, G. (2000). "Approaches to valuing the hidden hydrological services of wetland ecosystems." Ecological Economics 35: 63-74.

This paper investigates the role of the production function approach in capturing the value of hydrological services of wetland ecosystems. Hydrological research in the Hadejia-Nguru wetlands in northern Nigeria suggests that the major role of the wet season inundation of the wetlands is in recharging the underlying aquifers. This paper shows that the hydrological services extend beyond direct use values, and have a significant economic value associated with them. Whereas the direct benefits provided by the wetlands, such as floodplain agriculture, fishing and forestry, have previously been assessed, this paper synthesizes the results of two approaches to capture the value of indirect benefits derived from the role of the wetlands in replenishing and maintaining groundwater resources within the wetland area.

Adger, N., K. Brown, et al. (n.d). Towards estimating total economic value of forests in Mexico. London, Centre for Social and Economic Research on the Global Environment: 40.

Failure to account for the numerous functions and economic uses of forests have led to patterns of global forest use with many detrimental environmental consequences. This study demonstrates the economic techniques for estimating the Total Economic Value (TEV) of forests. For the Mexican forest estate, the results show an annual lower bound value of the services of the total forest area to be in the order of $4 billion. This aggregate value stems from the non-marketed services provided by non-consumptive use; from future potential uses of the genetic resources and from pure existence values; and the largest proportion of economic value coming from the functional values of hydrological and carbon cycling. However, only a proportion of this value can feasibly be 'captured' within Mexico: much of the benefit of Mexico's forests falls outside the country's borders, and is therefore not considered by forest users or national policy makers.

Alberta Agriculture Food and Rural Development (2002). Proceedings from "The Land Supports Us All". 2002 Land Use Conference, Edmonton, Alberta, Alberta Agriculture, Food and Rural Development, Information Packaging Centre.

To address the challenges brought about by the increasing and overlapping use of a finite land resource in Alberta, a three-day conference was held in January 2002. The "Land Supports Us All" Land Use Conference brought together the major sectors of Alberta, including municipal, provincial and federal representatives and the research community. The goal of this conference was to bring stakeholders together so that they could start to share their vision for a sustainable future given the overlapping demands for land.

Alexander, A., J. List, et al. (1998). "A method for valuing global ecosystem services." Ecological Economics 27: 161-170.

The goal of this paper is to provide an investigation of several approaches to valuing ecosystem services and to contribute additional techniques which may be used in evaluating 'green' GDP accounts. Our estimates focus on the ecosystem as a productive economic input, not a stock which is depreciated or depleted over time; as such, it differs with other concepts more frequently employed in green GDP accounting. Most of our results are derived from the analytical fiction that a single owner of the biosphere establishes a market for all ecological resources. This monopolist then appropriates all rents from the human population. The maximum amount the monopolist charges is first assumed to be world gross product less the global human subsistence level. In addition, we examine the excess rents available in factor markets using the assumption of weak complementarity between factor inputs and ecosystem services. We also provide more conservative estimates of the value of ecosystem services by investigating the sustainable price the monopolist could charge the global population and by exploring the effects of compensating wage differentials and a non-monopolist owner of the ecosystem.

Anielski, M. (2001). The Alberta genuine progress indicator (GPI) accounting project charting a sustainable future for all Canadians. Ottawa, The National Round Table on the Environment and the Economy: 29.

This document provides an overview of the Alberta Genuine Progress Indicator (GPI) Accounting Project. It was prepared for the Steering Committee of the National Round Table on the Environment and the Economy's Environment and Sustainable Development Indicators (ESDI) Initiative. In particular, the report examines:
The framework used to select the indicators:

- the theoretical basis/link to sustainability;
- how linkages and interrelationships can be inferred;
- the role of non-renewable resources;
- the main advantages and disadvantages of this approach.

The intended audience:

- how these indicators are intended to be used;
- any planned communication strategies.

The report also identifies key issues for the work of the ESDI Steering Committee.

Anielski, M. (2001). The Alberta GPI blueprint: The genuine progress indicator (GPI) sustainable well-being accounting system. Drayton Valley, The Pembina Institute: 126.

This document represents a blueprint for measuring and managing for the sustainable well-being of nations. It is the architectural companion or "methodology primer" to the report Alberta Sustainability Trends 2000: The Genuine Progress Indicators (GPI) Report 1961 to 1999 released April 23, 2001 (see www.pembina.org), which was the first application of the GPI sustainable well-being accounting methodology. This "blueprint" describes the rationale, structure and methods used in constructing a GPI System of Sustainable Well-being Accounts. By measuring the total and real wealth of nations, we are better equipped to ensure a sustainable future for future generations as well as our own.

The GPI accounting framework is an alternative to the current international System of National Accounts. Building on the traditional accounting language of "capital" and on accounting tools such as balance sheets, income statements and ledgers, the GPI accounting system offers a new tool for nations to measure, in an integrated manner, the condition, sustainability and monetary costs and benefits of human, social, natural and produced capital. The GPI accounting system was developed by considering some of the leading work for measuring economic, social and environmental progress in a holistic manner. Our hope is that researchers and policy analysts around the world will consider the merits of this new open architecture for measuring genuine well-being and the progress of nations, provinces, states and communities according to those parameters that make life worthwhile.

Anielski, M. and S. Wilson (2001). The Alberta GPI accounts: Forests. Drayton Valley, The Pembina Institute: 84.

This is one of 28 reports that provide background for the Genuine Progress Indicators (GPI) System of Sustainable Well-being Accounts. This report examines the trends in the sustainability and ecological health of Alberta's forests as a measure of the genuine well-being of Alberta's natural capital and ecosystem integrity. The report represents the continued development of forest resource accounts for Alberta that were initiated by Mark Anielski (formerly of Alberta Forestry, Lands and Wildlife, and Alberta Environment) to provide a meaningful accounting system that tracks the sustainability of forest capital. This report looks at several trends in some key indicators of both the biophysical condition of Alberta's forests as well as the economic returns to Albertans from developing forest and timber capital resources. Indicators such as the Timber Sustainability Index (TSI) are derived from detailed forest resource accounts that compare annual growth rates of timber with the annual depletion rates due to harvesting and natural disturbances by fire, insect and disease. This report also examines the condition of forest ecosystems by looking at the trends in the fragmentation of these ecosystems due to industrial development and linear disturbance. We also examine other forest ecosystem services including carbon sequestration and watershed services. Finally, the report examines the economic returns to consuming timber capital that contribute to Alberta's economic growth and prosperity; indicators such as forestry GDP, forest economic rent and jobs per unit of wood harvested. The report provides a forty-year picture of the sustainability of the living capital of Alberta's forest and asks the questions: are Alberta's forests sustainable over the long term and are there emerging risks to sustained timber harvest due to fire and other liabilities?

Anielski, M. and S. Wilson (2003). Counting Canada's natural capital: Assessing the real value of Canada's boreal ecosystems. Ottawa, The Canadian Boreal Initiative and The Pembina Institute.

This study reveals the broad range of ecological goods and services provided by Canada's boreal region. These have been organized into a BEWAS. The purpose of the BEWAS is to give Canadian decision makers a boreal natural capital "balance sheet" for assessing the sustainability, integrity, and full economic value of the boreal region. The balance sheet is broken down into three main accounting categories: 1. Natural capital accounts 2. Land accounts 3. Ecosystem service accounts. Using the BEWAS as an analytic and reporting framework, this study begins to estimate some of the economic value of the boreal region's many ecological goods and services. The purpose of such valuation work is to provide decision makers with a means of considering the full economic value of the many ecological goods and services of the boreal region when making decisions about its future.

Anielski, M. and S. Wilson (2007). The real wealth of the Mackenzie region: Assessing the natural capital values of a northern boreal ecosystem. Ottawa, The Canadian Boreal Initiative: 32.

This study is the first watershed-based natural capital review in Canada. Spanning 1.7 million square kilometres (or 170 million hectares), the Mackenzie watershed rivals the size and flow rates of the world's greatest river basins, including the Nile, Yangtse, and Amazon. The Mackenzie watershed is rich in other natural capital assets — intact forests, habitats for wildlife, rich sources of carbon, and vast deposits of oil, oil sands, natural gas and minerals. Yet, even given its significance, this great natural capital asset does not appear on Canada's national balance sheet nor do its ecological goods and services show up in the gross domestic product (GDP) — the traditional measure of economic progress.

The Canadian Boreal Initiative (CBI) has commissioned this study to help decision makers — federal, territorial, provincial and First Nations governments — make informed stewardship decisions that balance broader ecosystem and cultural values with sustainable economic growth. The study's primary goal was to construct a natural capital account for the Mackenzie watershed, including a total economic valuation of the market and non-market benefits of the watershed's natural capital.

This study builds on an earlier natural capital accounting study by the same authors completed in 2005, titled Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems, in which estimated ecosystem service values were contrasted with market (GDP) benefits of resource development. This study advances new valuation methodologies for ecological goods and services, building on the earlier Boreal wealth study, research by other ecological economists, and new carbon valuation methods, including the recent global carbon cost estimates by U.K. economist Sir Nicholas Stern. The study shows the importance and real socio-cultural-economic value of conserving natural capital, and balancing sustainable development with protecting intact ecosystems for future regional and national benefits.

Antle, J. and J. Stoorvogel (2006). "Predicting the supply of ecosystem services from agriculture." American Journal of Agricultural Economics 55(5): 1175-1180.

The purpose of this paper is to present a conceptual framework for the analysis of ES supply, and to discuss some of the data and modeling issues that arise in predicting farmers' participation in ecosystem service contracts and the supply of ES resulting from them. Two key features of agro-ecosystems that have been identified in the scientific literatures are the complexity of the biophysical and human environments in which they operate, and the complexity of the ecological and economic processes governing the systems. To frame the discussion, we outline a model of the supply of ES that illustrates the ways that spatial and system complexity can affect it. We use this model to discuss the data and modeling issues that arise in empirical implementation. We conclude with recommendations regarding modeling strategies that can provide sufficiently accurate and timely information needed to support informed policy decision making.

Armsworth, P. and J. Roughgarden (2001). "An invitation to ecological economics." Trends in Ecology & Evolution 16(5): 229-234.

The emerging interdisciplinary field of ecological economics should be a recognized research priority. Only through a combination of sound ecology and good economics can we hope to manage our exploitation of the biosphere in a manner that is both sustainable and efficient. This article is an invitation to ecologists to use economic tools and to participate in ecological economic debate. To this end, we review basic ecological economic concepts and discuss how the field has arisen, what benefits it offers, and what challenges it must overcome.

Babe, R. (2006). Culture of ecology: Reconciling economics and environment. Toronto, University of Toronto.

Mainstream economics, in particular the specialized school of environmental economics, "is a harmful, destructive, anti-environmental discursive system that needs to be radically reformulated if we are to avoid the continued, accelerating deterioration of our life-support system," declares Babe (media studies, U. of Western Ontario, Canada). He traces the development of economics and ecology as disciplines, comparing their main tenets and methodologies, and argues for a reformulation of economics in accordance with the principles of ecosystem interaction. He seeks to demonstrate that Aristotle, the ancient Jews, and other antiquarian thinkers had achieved better synthesis of environmental thought and economics and attacks the shattering of the synthesis in the writings of Thomas Hobbes and Adam Smith. He then critiques current day economics and its treatment of environmental concepts and information.

Badola, R. and S. Hussain (2005). "Valuing ecosystem functions: An empirical study on the storm protection function of Bhitarkanika mangrove ecosystem, India." Environmental Conservation 32(1): 85-92.

The ecosystem services provided by mangroves are often ignored in the ongoing process of mangrove conversion. Services provided by the Bhitarkanika mangrove ecosystem in India and estimated cyclone damage avoided in three selected villages, taking the cyclone of 1999 as a reference point, were valued by assessing the socio-economic status of the villages, the cyclone damage to houses, livestock, fisheries, trees and other assets owned by the people, and the level and duration of flooding. Eleven variables were used to compare damage in the villages, one protected by mangroves, one unprotected by mangroves, and the third possessing an embankment on its seaward side. Attitude surveys were carried out in 10% of the households in 35 villages located in the Bhitarkanika Conservation Area to assess local people's perceptions regarding the storm protection function of mangroves and their attitude towards mangrove forests generally. In the mangrove-protected village, variables had either the lowest values for adverse factors (such as damage to houses), or the highest values for positive factors (such as crop yield). The loss incurred per household was greatest (US$ 153.74) in the village that was not sheltered by mangroves but had an embankment, followed by the village that was neither in the shadow of mangroves or the embankment (US$ 44.02) and the village that was protected by mangrove forests (US$ 33.31). The local people were aware of and appreciated the functions performed by the mangrove forests in protecting their lives and property from cyclones, and were willing to cooperate with the forest department in mangrove restoration.

Balmford, A., A. Bruner, et al. (2002). "Economic reasons for conserving wild nature." Science 297: 950-953.

On the eve of the World Summit on Sustainable Development, it is timely to assess progress over the 10 years since its predecessor in Rio de Janeiro. Loss and degradation of remaining natural habitats has continued largely unabated. However, evidence has been accumulating that such systems generate marked economic benefits, which the available data suggest exceed those obtained from continued habitat conversion. We estimate that the overall benefit: cost ratio of an effective global program for the conservation of remaining wild nature is at least 100:1.

Banzhaf, S. and J. Boyd (2005). The architecture and measurement of an ecosystem services index. Discussion Paper. Washington, Resources for the Future: 57.

This paper describes the construction of an ecological services index (ESI). An ESI is meant to summarize and track over time the magnitude of beneficial services arising from the natural environment. A central task of this paper is to define rigorously ecosystem services so that services can be counted in an economically and ecologically defensible manner—a requirement if ecological contributions to welfare are to be incorporated into the national accounts. This paper advocates a particular economic structure and relates it to index theory and makes concrete recommendations for the measurement of such an index.

Baskin, Y. (1997). The work of nature: How the diversity of life sustains us. Washington, Island Press.

Baskin reports on the findings of an innovative ecological survey conducted in the hopes of answering the question, "What are the possible consequences of the accelerating losses in biodiversity?" Biodiversity is more than the earth's "lavish array of organisms," to use Baskin's lovely phrase; it embraces the myriad interactions among those species (at least 100 million, according to some estimates) that make the planet "hospitable for humanity." As scientists become increasingly attuned to the complexity of the interconnectedness of plants and animals, from the tiniest of microflora that keep our soil fertile, to the largest of mammals, they are beginning to recognize the functional role of each species in the ceaseless work of keeping our air and water clean. People do, indeed, need each and every life-form on the planet; the eradication of other species through the destruction of natural habitats will lead inexorably to the demise of their own.

Bennett, E., G. Peterson, et al. (2005). "Looking to the future of ecosystem services." Ecosystems 8: 125-132.

Ecosystem services—the benefits that people obtain from ecosystems—are essential to human existence, but demands for services often surpass the capacity of ecosystems to provide them. Lack of ecological information often precludes informed decision making about ecosystem services. The Millennium Ecosystem Assessment (MA) was conceived in part to provide the necessary ecological information to decision makers. To this end, the MA set out to address the stated needs and concerns of decision makers and examine the ecological dynamics and uncertainties underlying these concerns. To improve our understanding of their information needs and concerns, we interviewed 59 decision makers from five continents. The respondents indicated that although most people generally agree about the ideal state of the planet—free of poverty and extreme inequality, replete with cultural and biological diversity—they often disagree about the best way to achieve these goals. Further, although nonspecialists are generally concerned about the environment and may have a good understanding of some of issues, they often have a more limited grasp of the ecological dynamics that drive the issues of concern. We identify some of the principal uncertainties about ecosystem dynamics and feedbacks that underlie the concerns of decision makers. Each of the papers in this special feature addresses these ecological feedbacks from the perspective of a specific discipline, suggesting ways in which knowledge of ecological dynamics can be incorporated into the MA's assessment and scenario-building process.

Bingham, G., R. Bishop, et al. (1995). "Issues in ecosystem valuation: improving for decision making." Ecological Economics 14: 73-90.

In Spring 1991, the U.S. Environmental Protection Agency convened an expert group of ecologists, economists and other social scientists for the purpose of advancing the state of the art of ecosystem valuation methods. This Ecosystem Valuation Forum was organized as a dialogue because it has been clear from the outset that agreement even on the meaning of the term "ecosystem valuation" could not be taken for granted. Individuals from diverse disciplines, and from industry, environmental groups and government agencies disagree about what information about ecosystem services is needed, how it should be used and, therefore, what would constitute an advance in the methods that analysts should employ. The Forum discussed the varied ways in which experts from different disciplines approach valuation, what ecosystem attributes or services are important to value, and the factors that complicate the task of assigning values to ecosystem attributes. The Forum placed particular importance on approaching the problem of ecosystem valuation from the perspective of decision makers. Therefore, members discussed the variety of decision makers who might need valuation information, the controversy over where balancing decisions about costs and benefits should be made, and the implications for what information is needed within different institutional constraints. In addition, agency decision makers operate under real time and resource constraints. Thus, the Forum discussed the need to develop protocols that would guide analysts in a search for decisive information. The Forum concluded that the time is ripe for making new progress in solving some of these problems, while acknowledging that it may not be possible to develop a single unifying definition of value. Instead, the goal would be to understand how various concepts of value are structured, how they relate to each other, and how they can guide us toward a more integrated valuation process. The Forum recommended that next steps in addressing these issues be organized around case studies, particularly those that would enable researchers to improve linkages between ecological and economic methods and to develop improved protocols for valuation studies.

Binning, C., B. Baker, et al. (2000). Making farm forestry pay: Markets for ecosystem services. Canberra, Rural Industries Research and Development Corporation and CSIRO Wildlife & Ecology: 77.

This report addresses the challenge of how to make agroforestry (or farm forestry) pay by identifying key issues connected with providing incentives and commercialising the environmental and social values associated with agroforestry. It introduces the role of markets for environmental services in delivering ecological products to investors. Chapter 1 provides an introduction to agroforestry in Australia. In Chapter 2, the considerable opportunities for agroforestry in the Australian landscape are discussed, and then balanced by looking at the range of impeuiments for the uptake of agroforestry. Typical Australian incentives are discussed in Chapter 3 with a view to assessing how far the existing policy mix can take us in implementing agroforestry activities in Australia, particularly the low to medium rainfall zones. Following the conclusions reached on current incentives and policy alternatives, the role of ecosystem markets are examined in Chapter 4. The opportunities for ecosystem markets in delivering improved outcomes for tree plantings, including agroforestry are highlighted. A conceptual framework is introduced in some detail, leading to discussions on challenges for, and the transition to, markets for environmental services. Chapter 5 provides some case studies of existing market-based opportunities to invest in ecosystem services. Finally in Chapter 6, the report highlights a research agenda that will require further development over the coming years.

Binning, C. and P. Feilman (2000). Nature conservation and the non-government sector – A discussion paper. Canberra, CSIRO: 29.

This paper is aimed at understanding the role of the non-government sector in landscape conservation – that is it seeks to identify the mechanisms through which the natural resources of our regions, and the people who live in those regions, can be sustained by the non-government sector. The paper identifies the challenges involved in developing active partnerships for landscape conservation across a range of non-government organisations, businesses and governments.

Binning, C. and M. Young (1999). Conservation hindered: The impact of local government rates and State land taxes on the conservation of native vegetation. National R&D Program on Rehabilitation, Management and Conservation of Remnant Vegetation. Canberra, Environment Australia: 48.

This report forms a part of a larger project being undertaken by CSIRO Wildlife and Ecology which is identifying opportunities for the use of incentive-based instruments in the conservation of native remnant vegetation. This report evaluates the impact of property-based rates levied by local governments and State-based land taxes on the ability of landholders to conserve native vegetation. It does so with the objective of understanding how private investment in the conservation of native vegetation can be more effectively promoted in Australia.

Binning, C. and M. Young (n.d). Native vegetation: institutions, policies and incentives. Resource Futures Program, Dynamic Resource Accounting and Policy Evaluation Project CSIRO Wildlife and Ecology. Canberra, CSIRO: 64.

Native vegetation is amongst Australia's most precious and valuable natural assets. But native vegetation is under threat. Land clearing continues to outstrip replanting despite a commitment of over $1 billion by the Commonwealth government to these activities. Ultimately on-ground programs are required that target and reward land managers who actively manage areas of native vegetation on their land – be it private or public land. However, the project has revealed that the pathway to this outcome is rather more complex. Rather than focusing exclusively on land managers, it is necessary to understand the economic and social factors that are driving the land-uses and management practices that are causing the continuing loss of native vegetation. Conserving native vegetation demands that we understand and create markets that value the role of natural systems and ecological processes in sustaining landscapes. Landscapes and the issues embedded within them vary enormously, from the protection of remote wilderness areas to maintaining the productivity of agricultural regions and the quality of life in cities. This report sets out principles and guidelines for the design of institutions and policies for the conservation and sustainable use of native vegetation.

Binning, C. and M. Young (1999). Talking to the taxman about nature conservation: Proposals for the introduction of tax incentives for the protection of high conservation value native vegetation. National R&D Program on Rehabilitation, Management and Conservation of Remnant Vegetation. Canberra, Environment Australia: 56.

This report forms part of a larger project being undertaken by CSIRO Wildlife and Ecology which is identifying opportunities for the use of incentive-based instruments in the conservation of native remnant vegetation. This paper evaluates a range of proposals for providing tax incentives for the protection of native vegetation and biodiversity that is of high conservation value.

Binning, C., M. Young, et al. (1999). Beyond roads, rates and rubbish: Opportunities for local government to conserve native vegetation. National R&D Program on Rehabilitation, Management and Conservation of Remnant Vegetation Canberra, Environment Australia 148.

This report forms a part of a larger project being undertaken by CSIRO Wildlife and Ecology which is identifying opportunities for the use of incentive-based instruments in the conservation of native remnant vegetation. This document reports on the principal findings of a study that has evaluated the role of local government in managing native vegetation. It is clear that local governments are a key player in natural resource management, including native vegetation management.

Bishop, R. and D. Romano, Eds. (1998). Environmental resource valuation: Applications of the contingent valuation method in Italy, Springer.

Economic values are increasingly used in policy analysis and legal settings. With the growing recognition that many of the things that benefit or harm people are outside the market system, have come increasing efforts to develop nonmarket valuation techniques. One such technique is the contingent valuation method (CVM). CVM seeks to value environmental and other nonmarket goods and services by asking individuals about their values using survey methods. These procedures are different from the `revealed-preference' methods that economists have historically employed to estimate economic values.
Why depart from well-established revealed-preference procedures and apply a `stated-preference' method like CVM? For nonmarket goods and services, revealed-preference methods have two shortcomings that those applying CVM hope to avoid. First, revealed-preference methods involve econometric problems that have yet to be fully overcome. The second shortcoming of revealed-preference methods is that such methods, when applied to environmental amenities, are likely to be only partial measures of value.
Given the tremendous interest that exists in economic values and the limitations of revealed-preference methods, it is not surprising that interest in CVM has grown rapidly. *Environmental Resource Valuation* reviews the application of CVM and compares American experiences in nonmarket evaluation with those in other countries.

Bjorklund, J., K. Limburg, et al. (1999). "Impact of production intensity on the ability of the agricultural landscape to generate ecosystem services: An example from Sweden." Ecological Economics 29: 269-291.

This paper identifies a number of essential ecosystem services, and estimates their generation by the Swedish agricultural landscape under different production intensities. This is exemplified with data from a low-intensity period (1950s) and a high-intensity one (1990s). The services are described in qualitative and, to the extent possible, quantitative terms, and the ecological functions that support these services are identified. About 20% of Swedish agricultural land has been removed from production during the past 40 years. Production has been strongly intensified with respect to external inputs, and specialized regionally. Local landscape mosaics have been substantially altered, which resulted in a decreased ability of agricultural landscapes to support natural ecosystem components and processes. We argue that all of these changes affect the ability of the landscape to generate ecosystem services. Local, ecological 'goods and services' have largely been replaced by fossil fuel driven technology and the regulation of the system is now driven much more by external factors. However, there is no notable change in the system's ability to assimilate solar energy, measured by net primary production (NPP) and corrected for the cost of production (external inputs considered as foregone NPP). Most of the measures we derive indicate a loss of ecosystem services from the Swedish agricultural landscape. This is tantamount to losing an important form of 'local ecological insurance', and could lead to serious problems in a future with lower access to external resources, or with an altered energy policy.

Bockstael, N., R. Costanza, et al. (1995). "Ecological economic modeling and valuation of ecosystems." Ecological Economics 14: 143-159.

We are attempting to integrate ecological and economic modeling and analysis in order to improve our understanding of regional systems, assess potential future impacts of various land-use, development, and agricultural policy options, and to better assess the value of ecological systems. Starting with an existing spatially articulated ecosystem model of the Patuxent River drainage basin in Maryland, we are adding modules to endogenize the agricultural components of the system (especially the impacts of agricultural practices and crop choice) and the process of land-use decision making. The integrated model will allow us to evaluate the indirect effects over long time horizons of current policy options. These effects are almost always ignored in partial analyses, although they may be very significant and may reverse many long-held assumptions and policy predictions. This paper is a progress report on this modeling effort, indicating our motivations, ideas, and plans for completion.

Bolund, P. and S. Hunhammar (1999). "Ecosystem services in urban areas." Ecological Economics 29: 293-301.

Humanity is increasingly urban, but continues to depend on Nature for its survival. Cities are dependent on the ecosystems beyond the city limits, but also benefit from internal urban ecosystems. The aim of this paper is to analyze the ecosystem services generated by ecosystems within the urban area. 'Ecosystem services' refers to the benefits human populations derive from ecosystems. Seven different urban ecosystems have been identified: street trees; lawns: parks; urban forests; cultivated land; wetlands; lakes: sea; and streams. These systems generate a range of ecosystem services. In this paper, six local and direct services relevant for Stockholm are addressed: air filtration, micro climate regulation, noise reduction, rainwater drainage, sewage treatment, and recreational and cultural values. It is concluded that the locally generated ecosystem services have a substantial impact on the quality-of-life in urban areas and should be addressed in land-use planning.

Boumans, R., R. Costanza, et al. (2002). "Modeling the dynamics of the integrated earth system and the value of global ecosystem services using the GUMBO model." Ecological Economics 41: 529-560.

A global unified metamodel of the biosphere (GUMBO) was developed to simulate the integrated earth system and assess the dynamics and values of ecosystem services. It is a 'metamodel' in that it represents a synthesis and a simplification of several existing dynamic global models in both the natural and social sciences at an intermediate level of complexity. The current version of the model contains 234 state variables, 930 variables total, and 1715 parameters. GUMBO is the first global model to include the dynamic feedbacks among human technology, economic production and welfare, and ecosystem goods and services within the dynamic earth system. GUMBO includes modules to simulate carbon, water, and nutrient fluxes through the Atmosphere, Lithosphere, Hydrosphere, and Biosphere of the global system. Social and economic dynamics are simulated within the Anthroposphere. GUMBO links these five spheres across eleven biomes, which together encompass the entire surface of the planet. The dynamics of eleven major ecosystem goods and services for each of the biomes are simulated and evaluated. Historical calibrations from 1900 to 2000 for 14 key variables for which quantitative time-series data was available produced an average R2 of 0.922. A range of future scenarios representing different assumptions about future technological change, investment strategies and other factors have been simulated. The relative value of ecosystem services in terms of their contribution to supporting both conventional economic production and human well-being more broadly defined were estimated under each scenario, and preliminary conclusions drawn. The value of global ecosystem services was estimated to be about 4.5 times the value of Gross World Product (GWP) in the year 2000 using this approach. The model can be downloaded and run on the average PC to allow users to explore for themselves the complex dynamics of the system and the full range of policy assumptions and scenarios.

Boyd, J. (2006). The nonmarket benefits of nature: What should be counted in green GDP? Discussion Paper. Washington, Resources for the Future.

Green gross domestic product (green GDP) is meant to account for nature's value on an equal footing with the market economy. Several problems bedevil green GDP, however. One is that nature does not come prepackaged in units like cars, houses, and bread. Even worse, green GDP requires measurement of the benefits arising from public goods provided by nature for which there are no market indicators of value. So what should green GDP count? That is the subject of this paper. Ecological and economic theory are used to describe what should be counted—and what should not—if green GDP is to account for the nonmarket benefits of nature.

Boyd, J. and S. Banzhaf (2005). "Ecosystem services and government accountability: The need for a new way of judging nature's value." Resources Summer 2005: 16-19.

A brief guide to what ecosystem services really are, what they are not, and why we need a system of measuring them.

Boyd, J. and S. Banzhaf (2006). What are ecosystem services? The need for standardized environmental accounting units. Resources for the Future. Washington, Resources for the Future: 29.

This paper advocates consistently defined units of account to measure the contributions of nature to human welfare. We argue that such units have to date not been defined by environmental accounting advocates and that the term "ecosystem services" is too ad hoc to be of practical use in welfare accounting. We propose a definition, rooted in economic principles, of ecosystem service units. A goal of these units is comparability with the definition of conventional goods and services found in GDP and the other national accounts. We illustrate our definition of ecological units of account with concrete examples. We also argue that these same units of account provide an architecture for environmental performance measurement by governments, conservancies, and environmental markets.

Boyd, J. and L. Wainger (2003). Measuring ecosystem service benefits: The use of landscape analysis to evaluate environmental trades and compensation. Discussion Paper. Washington, Resources for the future: 156.

Ecosystem compensation and exchange programs require benefit analysis in order to guarantee that compensation or trades preserve the social benefits lost when ecosystems are destroyed or degraded. This study derives, applies, and critiques a set of ecosystem benefit indicators (EBIs). Organized around the concept of ecosystem services and basic valuation principles we show how GIS mappings of the physical and social landscape can improve understanding of the ecosystem benefits arising from specific ecosystems. The indicator system focuses on landscape factors that limit or enhance an ecosystem's ability to provide services and that limit or enhance the expected value of those services. The analysis yields an organized, descriptive, and numerical depiction of sites involved in specific mitigation projects. Indicator-based evaluations are applied to existing wetland mitigation projects in Florida and Maryland in order to practically illustrate the virtues and limitations of the approach.

Bradley, C. and C. Wallis (1996). Prairie ecosystem management: An Alberta perspective. Prairie Conservation Forum, Occasional Paper Number 2. Prairie Conservation Forum. Lethbridge, Prairie Conservation Forum: 29.

The purpose of developing a proposed framework for prairie ecosystem management is to provoke thought and discussion about the concepts of ecosystem management and their application to the prairies. Informal conversations at the PCES workshop, a workshop session on ecosystem management, and participants' responses to the questionnaire suggest general endorsement of the framework for prairie ecosystem management as presented in this document. The next important step, however, must be review by a broader audience and consideration of practical application of the concepts. Individuals involved in this initiative are working at clarifying and testing the concepts in their work and encourage you, the reader, to do the same.

Bruins, R. and M. Heberling, Eds. (2004). Economics and ecological risk assessment: applications to watershed management. Boca Raton, CRC Press.

The contributors of these 16 articles use an interdisciplinary approach in their assessment of watershed management techniques. They describe the background, concepts, and methods of watershed planning and management in the US as well as the idea of applying ecological risk assessment and economic risk analysis, the latter in the form of case studies. They address decision-making and uncertainty, determining the scale of intervention, and using existing frameworks in analysis and follow-through. They also describe applications of these concepts and methods in projects from across the US. In their conclusion the editors summarize the case studies, and call for further research and applications of methods that include both ecological and economic assessments, as well as interdisciplinary approaches to social and cultural concerns.

Carpenter, S. and M. Turner (2000). "Opening the black boxes: Ecosystem science and economic valuation." Ecosystems 3: 1-3.

The authors offer this set of commentaries to ecologists as a diverse, readable introduction to some of the major current and emerging issues in ecological valuation. Readers who seek a more comprehensive and thorough treatment of the subject will find many entry points to the current literature in this set of commentaries.

Chan, K., R. Shaw, et al. (2006). "Conservation planning for ecosystem services." PLOS Biology 4(11): 2138-2152.

Despite increasing attention to the human dimension of conservation projects, a rigorous, systematic methodology for planning for ecosystem services has not been developed. This is in part because flows of ecosystem services remain poorly characterized at local-to-regional scales, and their protection has not generally been made a priority. We used a spatially explicit conservation planning framework to explore the trade-offs and opportunities for aligning conservation goals for biodiversity with six ecosystem services (carbon storage, flood control, forage production, outdoor recreation, crop pollination, and water provision) in the Central Coast ecoregion of California, United States. We found weak positive and some weak negative associations between the priority areas for biodiversity conservation and the flows of the six ecosystem services across the ecoregion. Excluding the two agriculture-focused services—crop pollination and forage production—eliminates all negative correlations. We compared the degree to which four contrasting conservation network designs protect biodiversity and the flow of the six services. We found that biodiversity conservation protects substantial collateral flows of services. Targeting ecosystem services directly can meet the multiple ecosystem services and biodiversity goals more efficiently but cannot substitute for targeted biodiversity protection (biodiversity losses of 44% relative to targeting biodiversity alone). Strategically targeting only biodiversity plus the four positively associated services offers much promise (relative biodiversity losses of 7%). Here we present an initial analytical framework for integrating biodiversity and ecosystem services in conservation planning and illustrate its application. We found that although there are important potential trade-offs between conservation for biodiversity and for ecosystem services, a systematic planning framework offers scope for identifying valuable synergies.

Chavas, J. (2000). "Ecosystem valuation under uncertainty and irreversibility." Ecosystems 3: 11-15.

This article focuses on the effects of uncertainty and irreversibility, and their role in natural resource valuation. The interactions between uncertainty and ecosystem dynamics are examined and their implications for environmental management are discussed.

Chee, Y. E. (2004). "An ecological perspective on the valuation of ecosystem services." Biological Conservation 120: 549-565.

This paper presents a critical review on the neoclassical economic framework, tools used for economic valuation of ecosystem services and the economic welfare approach to collective decision-making, from an ecological perspective. The applicability of the framework and techniques for valuing ecosystem services are evaluated in light of the challenges posed by the complex, non-linear nature of many ecosystem services. Decisions concerning ecosystem management are often complex, socially contentious and fraught with uncertainty. Although judicious application of economic valuation techniques to ecosystem services can provide valuable information for conceptualizing decision choices and evaluating management options, there are serious limitations in the economic welfare approach to decision-making. These shortcomings and their implications for ecosystem management are elucidated and alternative approaches that emphasize participation, explicit treatment of uncertainty and transparent decision-making processes are discussed.

Chichilnisky, G. and G. Heal (1998). "Economic returns from the biosphere." Nature 391: 629-630.

This short article proposes various economic instruments that would allow investors to obtain economic returns from environmental assets, such as forests and landscapes, while ensuring their conservation.

Chichilnisky, G. and G. Heal, Eds. (2000). Environmental markets: Equity and efficiency. Economics for a sustainable earth. New York, Columbia University Press.

This is the second book in a series studying the economic implications of human domination of the planet. The first, Valuing the Future: Economic Theory and Sustainability (Heal 1998) addressed the conceptual issues raised by concerns about sustainability.

Coggan, A. and S. Whitten (2005). Exploring development offsets as a tool for conserving ecosystem services: Deciding on a policy approach – why market-based instruments (MBIs) and which kind? Canberra, CSIRO Sustainable Ecosystems.

This paper is the second paper in a series describing the impact of rural residential development on ecosystem services and outlining a market based approach to maintain and protect ecosystem services. In this paper it is recommended that an approach that requires both developers and non-developers to meet targets but allows flexibility with how the targets are met is the most effective, efficient and equitable approach to achieving targets. How this might be done is the focus of this paper.

Coggan, A., S. Whitten, et al. (2005). Exploring development offsets as a tool for conserving ecosystem services: Ecosystem services and rural residential development – a case study of the Murrindindi Shire of Victoria. Canberra, CSIRO Sustainable Ecosystems: 28.

This paper is the first paper in a series describing the impact of rural residential development on ecosystem services and outlining a market based approach to maintain and protect ecosystem services during rural residential development. This research report is the first in a series of papers exploring the policy options available for the conservation of ecosystem services whilst also allowing for RRD. This paper explores the questions: What are ecosystem services?; which ecosystem services are impacted by rural residential development and why?; why are ecosystem services under threat in the context of rural residential and lifestyle farming land uses in the Murrindindi Shire? This paper concludes that there are a number of gaps in the information required to fully describe the problem. These gaps are primarily associated with understanding the cause and effect relationships between the type of rural residential development and the provision of ecosystem services.

Coggan, A., S. Whitten, et al. (2005). Nesting MBIs in current institutions and structures – can it be done and what are the implications? 49th Annual Conference of the Australian Agricultural and Resource Economics Society. Coffs Harbour, CSIRO Sustainable Ecosystems.

Market based instruments are becoming a 'mainstream' policy instrument for managing a wide range of environmental issues. Despite this, there are many issues that need to be carefully considered in the design of such an instrument if an MBI is to cost effectively achieve the environmental objectives desired. One such consideration is how the MBI sits within the currently operating institutional frameworks. This paper illustrates this concept through a case study of the application of a development offset MBI to achieve desired development and enhanced ecosystem services in the Murrindindi Shire of Victoria, Australia.

Committee on Assessing and Valuing the Services of Aquatic and Terrestrial Ecosystems (2005). Valuing ecosystem services: toward better environmental decision-making. Washington, National Academies Press.

Ecosystems provide a wide variety of marketable goods, fish and lumber being two familiar examples. However, society is increasingly recognizing the myriad functions—the observable manifestations of ecosystem processes such as nutrient recycling, regulation of climate, and maintenance of biodiversity—that they provide, without which human civilizations could not thrive. Derived from the physical, biological, and chemical processes at work in natural ecosystems, these functions are seldom experienced directly by users of the resource. Rather, it is the services provided by ecosystems, such as flood risk reduction and water supply, together with ecosystem goods, that create value for human users and are the subject of this report.

Common, M. and S. Stagal (2005). Ecological economics: An introduction. New York, Cambridge University Press.

Taking as its starting point the interdependence of the economy and the natural environment, this book provides a comprehensive introduction to the emerging field of ecological economics. The authors, who have written extensively on the economics of sustainability, build on insights from both mainstream economics and ecological sciences. Part I explores the interdependence of the modern economy and its environment, while Part II focuses mainly on the economy and on economics. Part III looks at how national governments set policy targets and the instruments used to pursue those targets. Part IV examines international trade and institutions, and two major global threats to sustainability - climate change and biodiversity loss. Assuming no prior knowledge of economics, this textbook is well suited for use on interdisciplinary environmental science and management courses. It has extensive student-friendly features including discussion questions and exercises, keyword highlighting, real-world illustrations, further reading and website addresses.

Considinea, T. and D. Larson (2006). "The environment as a factor of production." Journal of Environmental Economics and Management 52: 645-662.

This paper uses firm-level data about electric utilities to develop an empirical model of how electric utilities use and bank SO2 pollution permits under the Acid Rain Program. The empirical model considers emissions, fuels, and labor as variable inputs with quasi-fixed stocks of permits and capital. Consequently, substitution possibilities between the environment and other production factors can be measured and tested. The results reveal substantial substitution between emissions, permit stocks, capital, fuel, and labor. The empirical findings also indicate that firms bank permits primarily as a hedge against uncertainty and for other firm-specific reasons. Overall, the results suggest that cap-and-trade approaches can reduce the cost of meeting environmental goals by providing a mechanism for addressing regulatory and market risks and by signaling an appropriate price for factor use, especially irreversible capital investments.

Cork, S. (2001). Ecosystem services: The many ways in which biodiversity sustains and fulfills human life. In Food for Healthy People and a Healthy Planet. Internet conference, Nature and Society Forum.

Ecosystems are declining worldwide, largely due to ignorance of their value to humans and inadequate social and economic mechanisms to encourage individuals to invest in maintaining them. The concept of Ecosystem Services is becoming popular as a way to encourage discussion about the dependence of humans on nature and what that means socially and economically. Ecosystem services are transformations of natural assets (soil, water, air, and living organisms) into products that are important to humans. Examples include: provision of clean air and water; maintenance of soil fertility; maintenance of liveable climates; pollination of crops and other vegetation; control of potential pests; provision of genetic resources; production of food and fibre; and provision of cultural, spiritual and intellectual experiences. The value of ecosystem services to humans comes from their role in supporting our lives, their cheapness, and our limited ability to replace them with human-engineered alternatives. The problems we have in maintaining them come about because our economic systems don't cope well with goods and services that are publicly owned. This paper discusses the importance of ecosystem services for supporting food production and sustaining and fulfilling human populations. It briefly discusses an initiative being taken in Australia to apply the concept of ecosystem services to addressing the big drivers of ecosystem decline.

Cork, S. (2002). Ecosystem services and institutional rules. FutureScape: Exploring the Interaction between the Environment, Economy and Society. Sydney, Nature Conservation Council of NSW.

Environmental problems often arise from deficient, uncertain or confusing information about what ecosystem goods and services are available, how they are important to humans, who benefits and over what scales, combined with incomplete, inconsistent or unenforceable rules, rights and responsibilities. Establishing rules, rights and responsibilities at the range of spatial and temporal scales at which ecosystems function is a major challenge. Furthermore, the costs of implementing regimes of property rights and responsibilities can be beyond many land owners and managers. The concept of ecosystem services is being adapted and tested in Australia as a way to address some of the limitations of information and institutional rules. It attempts to express the benefits of ecosystems in language and concepts that the majority of land managers and users can understand and identify with, and it lays the foundations for developing formal and informal markets in which a fuller range of the beneficiaries of ecosystems contribute to the costs of their maintenance.

Cork, S. (2002). Identifying the opportunities: How the concept of ecosystem services can help. 8th National Conference and Workshop on the Productive Use and Rehabilitation of Saline Land, Fremantle.

The concept of Ecosystem Services provides a practical framework for addressing these and other key issues. It has become increasingly popular over recent decades as a way to recognize the dependence of humans on nature. In this paper, I explore some ways in which the concept of ecosystem services can help identify new opportunities for productive use and rehabilitation of saline lands.

Cork, S., W. Proctor, et al. (2002). "The ecosystem services project: Exploring the importance of ecosystems to people." Ecological Management & Restoration 3(2): 143-146.

This article provides an overview of the Ecosystem Services Project in Australia.

Cork, S. and D. Shelton (2000). The nature and value of Australia's ecosystem services: A framework for sustainable environmental solutions. Sustainable Environmental Solutions for Industry and Government, Queensland Environmental Conference.

A major reason for seeking sustainable environmental solutions is to maintain the benefits that come to humans from nature and its components. The term "Ecosystem Services" has been coined to describe these benefits. Ecosystem services include provision of clean air and water, natural fertilisation and nutrient cycling in soils, mitigation of climate, pollination of plants including crops, control of pests, provision of genetic resources, production of goods like food, fuel and fibre, maintenance of cultural and social values, and others. Most ecosystem services are not adequately considered in decision making and policy development because there is insufficient knowledge about the processes that deliver the services and because there are not adequate methods for assessing impacts on them in terms that can be compared with other policy or decision options. The Myer Foundation, as part of the Sidney Myer Centenary Celebration 1899-1999, has provided seed funding for a project involving CSIRO and a wide range of land managers, community groups, land management agencies, scientists and economists. The project aims to provide a detailed assessment of the goods and services coming from a range of Australian ecosystems, an assessment of the consumers and consumption of these services, and an evaluation of the economic costs and benefits of the services under future management scenarios. This paper outlines the concept of ecosystem services and its role as a conceptual framework for environmental decisions, discusses approaches to assessing the nature and value of ecosystem services, and describes the project itself.

Cork, S., D. Shelton, et al. (2001). A framework for applying the concept of ecosystem services to natural resource management in Australia. Third Australian Stream Management Conference. Brisbane, Cooperative Research Centre for Catchment Hydrology: 6.

Ecosystems are declining worldwide, largely due to ignorance of their value to humans and inadequate social and economic mechanisms to encourage individuals to invest in maintaining them. The concept of Ecosystem Services is becoming popular as a way to encourage discussion about the dependence of humans on nature and what that means socially and economically. Ecosystem services are transformations of natural assets (soil, water, air, and living organisms) into products that are important to humans. Examples include: provision of clean air and water; maintenance of soil fertility; maintenance of liveable climates; pollination of crops and other vegetation; control of potential pests; provision of genetic resources; production of food and fibre; and provision of cultural, spiritual and intellectual experiences. The value of ecosystem services to humans comes from their role in supporting our lives, their cheapness, and our limited ability to replace them with human-engineered alternatives. The problems we have in maintaining them come about because our economic systems don't cope well with goods and services that are publicly owned. This paper describes a framework for identifying the services coming from ecosystems around Australia, for analysing the ecological, social and economic problems and opportunities presented, and for exploring new ways to encourage investment in maintaining ecosystem services. The framework focuses on co-learning between scientists, economists and community members, and emphasises the need to communicate the results in ways that support decision-making at all levels. Since water and waterways underpin all ecosystem services, this approach also offers a framework for defining the health of waterways and managing them for healthy, productive and sustainable human communities.

Costanza, R. (1997). An introduction to ecological economics. Boca Raton, St. Lucie Press.

Ecological economics is a way of rethinking the relationship between humans & the environment & working out the implications of how we manage our lives & the planet. An Introduction to Ecological Economics offers a starting point for undergraduate & graduate students & environmental professionals interested in this transdisciplinary field. Beginning in Section 1 with a description of some current problems in society & their underlying causes, Section 2 then takes a historical perspective to explain how world views regarding economics & ecology have evolved. Section 3 presents the fundamental principles of ecological economics, & Part 4 outlines & discusses a set of policies for creating a sustainable society as well as instruments that could be used to implement those policies. A conclusions section summarizes the main points of the book & proposes prospects for the future.

Costanza, R., Ed. (2001). Institutions, ecosystems and sustainability. Boca Raton, Lewis Publishers.

Institutions, Ecosystems and Sustainability focuses on long-term, sustainable natural resource management at the local, national, and international levels. Traditional management practices that do well at the local level cannot be expected to do equally well on a national or global scale. When local land management is superseded by national or international management practices, local ecosystems frequently suffer. This book provides simulation exercises to explore the consequences of social institutions and a discussion of the progress being made in developing a broad global data base to test hypothesis about the relationship between ecosystems and social institutions.

Costanza, R. (2001). "Visions, values, valuation and the need for an ecological economics." Bioscience 51(6): 459-468.

Costanza argues in this article that problem solving in complex human dominated ecosystems requires active and ongoing visioning; systematic analysis consistent with the vision; and implementation of the appropriate vision. Today's scientists according to Costanza are only interested in step 2.

Costanza, R. (2003). "Social goals and the valuation of natural capital." Environmental Monitoring and Assessment 86: 19-28.

Valuation ultimately refers to the contribution of an item to meeting a specific goal or objective. Conventional economic valuation is based on the goal of allocative efficiency. But other social goals may be equally, if not more, important. For example, the goals of social fairness and ecological sustainability have been identified as being at least of the same level of importance as allocative efficiency. This paper looks at the role of social goals in determining the basis for valuation of natural capital and ecosystem services, and sketches the characteristics of a system of valuation that would give equal weight to all three of the major social goals mentioned above. It also places these goals within a more comprehensive conceptual model of the economy and its relationship to the ecological life support system in which it is embedded.

Costanza, R. (2004). "Value theory and energy." Encyclopedia of Energy (6): 337-346.

The concepts of value system, value, and valuation have many meanings and interpretations and a long history in several disciplines. This article provides a survey of some of these meanings to set the stage for a discussion of the relationship between energy and value. There is clearly not one "correct" set of concepts or techniques to address this important issue. Rather, there is a need for conceptual pluralism and thinking "outside the box." After a long and interesting history, the issue of value is now going through another period of rapid development that should help us to make better, and more sustainable, decisions, not only as individuals but also as groups, communities, and stewards of the entire planet.

Costanza, R., R. d' Arge, et al. (1997). "The value of the world's ecosystem services and natural capital." Nature 387: 253-260.

This is a seminal article in the valuation of ecosystem services. This study estimates that the annual value of these services is US$16-54 trillion, with an average estimated at US$33 trillion which is 1.8 times the current global GNP. It is also noted that if ecosystems were actually paid for, their value to the global economy would be very different from what it is today. Further, because ecosystem services are largely outside the market and uncertain, they are too often ignored or undervalued, leading to the error of constructing projects whose social costs far outweigh their benefits.

Costanza, R., R. d'Arge, et al. (1998). "The value of ecosystem services: Putting the issues in perspective." Ecological Economics 25: 67-72.

This article is a response to the critics of the authors' Nature paper. It was noted that the 1997 article was an attempt to synthesize existing information to address a new and important question, and to stimulate additional research and debate. The authors of that paper use this article to encourage all those concerned with ecosystem services and the sustainability of the planet to actively participate in this work.

Costanza, R. and H. Daly (1992). "Natural capital and sustainable development." Conservation Biology 6: 37-46.

This article discusses methodological issues concerning the substitutability of manufactured for natural capital, quantifying ecosystem services and natural capital, and the role of the discount rate in valuing natural capital. We differentiate the concepts of growth (material increase in size) and development (improvement in organization without size change. Finally, we suggest some principles of sustainable development and describe why maintaining natural capital stocks is a prudent and achievable policy for ensuring sustainable development.

Costanza, R., J. Ericksona, et al. (2004). "Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden County and Burlington, from 1950 to 2000." Ecological Economics 51: 139-155.

The Genuine Progress Indicator (GPI), a version of the Index of Sustainable Economic Welfare (ISEW), is a significantly more comprehensive approach to assessing economic progress than conventional measures like gross domestic product (GDP). GPI adjusts for income distribution effects, the value of household and volunteer work, costs of mobility and pollution, and the depletion of social and natural capital. ISEW or GPI have been estimated for several countries around the world and a few Canadian provinces, but we report here on the first multi-scale application at the city, county and state levels in Vermont, USA. We show that it is feasible to apply the GPI approach at these smaller scales and to compare across scales and with the national average. Data limitations and problems still exist, but potential solutions to these problems also exist. All three Vermont scales had significantly higher GPI per capita since 1980 than the national average, indicating the major differences that can exist within countries. The GPI per capita for all Vermont scales was similar to the national average in the 1950–1980 period, but more than twice the national average by 2000. The main factors explaining this difference had to do with Vermont's much better environmental performance than the national average in the post-1980 period.

Costanza, R. and S. Farber (2002). "Introduction to the special issue on the dynamics and value of ecosystem services: Integrating economic and ecological perspectives." Ecological Economics 41: 367-373.

This special issue represents the output of a 3-year working group supported by the National Center for Ecological Analysis and Synthesis (NCEAS), plus a few additional contributions. The papers cover conceptual, empirical and modeling issues concerning the dynamics and valuation of ecosystem services. They include discussions of the nature of value, the dynamics of complex adaptive systems, links between fairness and valuation, and global estimates of the value of ecosystem services using various models and databases. Taken together they represent a unique set of perspectives and a unique synthesis of the valuation issue. They provide fresh answers to some long-standing questions, and in the process raise new and interesting questions about valuing ecosystem services.

Costanza, R., S. Farber, et al. (1989). "Valuation and management of wetlands ecosystems." Ecological Economics 1: 335-361.

In this paper we (a) discuss the fundamental theoretical and practical problems underlying natural resource valuation; (b) summarize our methods and findings for Louisiana wetlands; and (c) elaborate on some of the more recalcitrant problems attending applied natural resource valuation, including discounting and dealing with uncertainty and imprecision. The discount rate makes more difference in the final result than any other one factor, and yet there is much disagreement about the appropriate approach to discounting natural resources. We discuss the discounting problem as applied to natural resources and argue for lower discount rates for valuing renewable natural resources than apply for other aspects of the economy. It now seems clear that no reasonable amount of effort will produce very precise estimates of wetland values, and we suspect this is also the case for several other classes of natural resources. We elaborate a Wetlands Assurance Bonding system to address these problems.

Costanza, R., D. Sternb, et al. (2004). "Influential publications in ecological economics: A citation analysis." Ecological Economics 50: 261-292.

We assessed the degree of influence of selected papers and books in ecological economics using citation analysis. We looked at both the internal influence of publications on the field of ecological economics and the external influence of those same publications on the broader academic community. We used four lists of papers and books for the analysis: (1) 92 papers nominated by the Ecological Economics (EE) Editorial Board; (2) 71 papers that were published in EE and that received 15 or more citations in all journals included in the Institute for Scientific Information (ISI) Citation Index; (3) 57 papers that had been cited in EE 15 or more times; and (4) 77 monographs and edited books that had been cited in EE 15 or more times. In all, we analyzed 251 unique publications. For each publication, we counted the total number of ISI citations as well as the total number of citations in EE. We calculated the average number of citations per year to each paper since its publication in both the ISI database and in EE, along with the percentage of the total ISI citations that were in EE.

Costanza, R., L. Wainge, et al. (1993). "Modeling complex ecological economic systems: Toward an evolutionary, dynamic understanding of people and nature." Bioscience 43: 545-555.

Through their analysis, the authors conclude that opportunities in modeling complex ecological economic systems can be divided into three broad, and interdependent categories. They are: application of the evolutionary paradigm; scale and hierarchy considerations; and the nature and predictability in modeling ecological economic systems.

Creedy, J. and A. Wurzbacher (2001). "The economic value of a forested catchment with timber, water and carbon sequestration benefits." Ecological Economics 38: 71-83.

This paper examines the optimal management strategy for a forested catchment that yields timber, water and carbon sequestration benefits. The Faustmann multiple rotation model is extended to allow for the maximisation of the net present value of these timber and non-timber benefits. The model is applied to the Thomson Catchment in Central Gippsland, Victoria. Carbon sequestration benefits are modelled via total stand biomass accumulation. The cost of carbon release back into the atmosphere upon logging is estimated as a function of rotation age using an adjusted pulpwood/sawlog ratio. The allowance for both non-timber benefits is found to lengthen the optimal rotation, in a large range of cases to infinity.

Cunningham, S., F. FitzGibbon, et al. (2002). "The future of pollinators for Australian agriculture." Australian Journal of Agricultural Research 53: 893-900.

Agriculture in Australia is highly dependent on insect pollination, of which most pollination is an unpaid service by native insects and a smaller amount is provided as a paid service by beekeepers. Pollination is threatened by misuse of insecticides and the loss of remnant vegetation, but most potently by the likelihood that the honeybee mite will enter the country. The authors assert that now is the time to prepare for the effects of these changes by protecting and managing remnant vegetation.

Curtis, I. (2004). "Valuing ecosystem goods and services: A new approach using a surrogate market and the combination of a multiple criteria analysis and a Delphi panel to assign weights to the attributes." Ecological Economics 50: 163-194.

A new approach to valuing ecosystem goods and services (EGS) is described which incorporates components of the economic theory of value, the theory of valuation (US ~ appraisal), a multi-model multiple criteria analysis (MCA) of ecosystem attributes, and a Delphi panel of experts to assign weights to the attributes. The total value of ecosystem goods and services in the various tenure categories in the Wet Tropics World Heritage Area (WTWHA) in Australia was found to be in the range AUD$188 to $211 million year, or AUD$210 to 236 ha year across tenures, as at 30 June 2002. Application of the weightings assigned by the Delphi panelists and assessment of the ecological integrity of the various tenure categories resulted in values being derived for individual ecosystem services in the World Heritage Area. Biodiversity and refugia were the two attributes ranked most highly at AUD$18.6 to $20.9 million year and AUD$16.6 to $18.2 million year, respectively.

Daily, G., Ed. (1997). Nature's services: Societal dependence on natural ecosystems. Washington, Island Press.

Life itself as well as the entire human economy depends on goods and services provided by earth's natural systems. The processes of cleansing, recycling, and renewal, along with goods such as seafood, forage, and timber, are worth many trillions of dollars annually, and nothing could live without them. Yet growing human impacts on the environment are profoundly disrupting the functioning of natural systems and imperiling the delivery of these services. Nature's Services brings together world-renowned scientists from a variety of disciplines to examine the character and value of ecosystem services, the damage that has been done to them, and the consequent implications for human society. Contributors including Paul R. Ehrlich, Donald Kennedy, Pamela A. Matson, Robert Costanza, Gary Paul Nabhan, Jane Lubchenco, Sandra Postel, and Norman Myers present a detailed synthesis of our current understanding of a suite of ecosystem services and a preliminary assessment of their economic value. Chapters consider: major services including climate regulation, soil fertility, pollination, and pest control philosophical and economic issues of valuation case studies of specific ecosystems and services implication of recent findings and steps that must be taken to address the most pressing concerns Nature's Services represents one of the first efforts by scientists to provide an overview of the many benefits and services that nature offers to people and the extent to which we are all vitally dependent on those services. The book enhances our understanding of the value of the natural systems that surround us and can play an essential role in encouraging greater efforts to protect the earth's basic life-support systems before it is too late.

Daily, G., S. Alexander, et al. (1997). "Ecosystem services: Benefits supplied to human societies by natural ecosystems." Issues in Ecology(2).

Historically, the nature and value of Earth's life support systems have largely been ignored until their disruption or loss highlighted their importance. For example, deforestation has belatedly revealed the critical role forests serve in regulating the water cycle – in particular, in mitigating floods, droughts, the erosive forces of wind and rain, and silting of dams and irrigation canals. Today, escalating impacts of human activities on forests, wetlands, and other natural ecosystems imperil the delivery of such services. The primary threats are land use changes that cause losses in biodiversity as well as disruption of carbon, nitrogen, and other biogeochemical cycles; human-caused invasions of exotic species; releases of toxic substances; possible rapid climate change; and depletion of stratospheric ozone.

Based on available scientific evidence, we are certain that:

· Ecosystem services are essential to civilization.

· Ecosystem services operate on such a grand scale and in such intricate and little-explored ways that most could not be replaced by technology.

· Human activities are already impairing the flow of ecosystem services on a large scale.

· If current trends continue, humanity will dramatically alter virtually all of Earth's remaining natural ecosystems within a few decades.

In addition, based on current scientific evidence, we are confident that:

· Many of the human activities that modify or destroy natural ecosystems may cause deterioration of ecological services whose value, in the long term, dwarfs the short-term economic benefits society gains from those activities.

· Considered globally, very large numbers of species and populations are required to sustain ecosystem services.

· The functioning of many ecosystems could be restored if appropriate actions were taken in time.

We believe that land use and development policies should strive to achieve a balance between sustaining vital ecosystem services and pursuing the worthy short-term goals of economic development.

Daily, G. and K. Ellison (2003). The new economy of nature: The quest to make conservation profitable. Washington, Island Press.

Why shouldn't people who deplete our natural assets have to pay, and those who protect them reap profits? Conservation-minded entrepreneurs and others around the world are beginning to ask just that question, as the increasing scarcity of natural resources becomes a tangible threat to our own lives and our hopes for our children. The New Economy of Nature brings together Gretchen Daily, one of the world's leading ecologists, with Katherine Ellison, a Pulitzer-prize winning journalist, to offer an engaging and informative look at a new "new economy" – a system recognizing the economic value of natural systems and the potential profits in protecting them. Through engaging stories from around the world, the authors introduce readers to a diverse group of people who are pioneering new approaches to conservation. We meet Adam Davis, an American business executive who dreams of establishing a market for buying and selling "ecosystem service units;" John Wamsley, a former math professor in Australia who has found a way to play the stock market and protect native species at the same time; and Dan Janzen, a biologist working in Costa Rica who devised a controversial plan to sell a conservation area's natural waste-disposal services to a local orange juice producer. Readers also visit the Catskill Mountains, where the City of New York purchased undeveloped land instead of building an expensive new water treatment facility; and King County, Washington, where county executive Ron Sims has dedicated himself to finding ways of "making the market move" to protect the county's remaining open space. Daily and Ellison describe the dynamic interplay of science, economics, business, and politics that is involved in establishing these new approaches and examine what will be needed to create successful models and lasting institutions for conservation. The New Economy of Nature presents a fundamentally new way of thinking about the environment and about the economy, and with its fascinating portraits of charismatic pioneers, it is as entertaining as it is informative.

Daily, G., T. Söderqvist, et al. (2000). "The value of nature and the nature of value." Science 289(5478): 395-396.

The authors submit the ecological basis for valuation, the principles, the scope and limitations, and what is referred to as the state of the art in terms of ecosystem valuation to a policy forum for debate.

Daily, G. and B. Walker (2000). "Seeking the great transition." Nature 403: 243-245.

This is a commentary. Environmentally sustainable economies are unachievable without enhanced participation of the private sector. Scientists must facilitate this process.

Daly, H. (2003). Ecological economics: The concept of scale and its relation to allocation, distribution, and uneconomic growth. Canadian Society for Ecological Economics, Jasper.

My discussion is in five parts. First, I look at ecological economics from the outside by summarizing the views of some scholars from other disciplines who have recently taken an interest in ecological economics and compared it quite favorably to neoclassical economics. Second, a look at the main features and issues in ecological economics, noting differences and questions under debate with mainline neoclassical economics. Third, a look at the meanings of economic growth, and the specific issue of economic growth versus uneconomic growth in the scale of the physical economy. Fourth, some policy implications from ecological economics about avoiding uneconomic growth by seeking a steadystate economy at or near the optimum scale. Fifth, I consider some alternative formulations on why optimal allocation presupposes a given scale, as well as a given distribution.

Daly, H. and J. Farley (2003). Ecological economics: principles and applications. Washington, Island Press.

This introductory textbook describes the basics of traditional neoclassical economic thought and also examines the connections between economic growth, environmental degradation, and social inequity. The volume opens with a discussion of the role of the earth's biotic and abiotic resources in sustaining life. The rest of the text is organized around the main fields in traditional economics: microeconomics, macroeconomics, and international economics.

For environmental economists, this book is must reading. Two refrains pervade the book. The first is that infinite economic growth is impossible in a finite world. This raises the question of scale: just what are the limits to human economic activity in a finite world? Environmental economics neglects this issue. Ecological economics addresses scale as a central issue, thereby delineating itself from environmental economics. The second refrain is that neoclassical economics fails to properly value and account for the services that the natural world provides. Therefore, humankind is blithely exceeding the sustainability of natural systems. Fundamental principles and controversial policies are clearly presented. Moral questions, such as intergenerational equity, are raised and remain open to debate. This is an important book because of the challenges it presents, not the answers it gives.

Davidson, S. (2000). "What price biodiversity?" Ecos 102: 10-13.

Davidson provides an outline for a collaborative beginning for something that is rarely traded, yet sustains life on earth.

de Groot, R. (1992). Functions of nature: Evaluation of nature in environmental planning, management and decision making Groningen, Wolters-Noordhoff.

Decision-makers are constantly calling for better practical "tools" to help them identify economically and ecologically sound projects. Such tools must be scientifically defensible and reproducible within a consistent framework, yet flexible enough to apply to a broad range of situations. Perhaps most important, they should be accessible to analysts from many disciplines without necessarily requiring years of study and specialized training. *Functions of Nature* introduces such a tool in a carefully thought-out and tested guide and checklist of 37 "environmental functions". It will appeal to many policymakers, analysts, educators, and students dealing with environmental and economic issues. Although *Functions of Nature* is written primarily from an ecological perspective, its basic hypothesis is that the concept of "environmental function" can help unify the disciplines of ecology and economics. The book thus commences with a detailed account of the 37 environmental functions, and is followed by a concise overview of methods for establishing their socio-economic value. Three case studies – a tropical moist forest ecosystem, a temperate wetland ecosystem (the Dutch Wadden Sea), and an oceanic archipelago (the Galapagos) – provide practical examples of the tool's application. Valuations of ecosystem functions in these studies show that meaningful analyses can be conducted even if uncertainty is pervasive.

de Groot, R. (2006). "Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes." Landscape and Urban Planning 75: 175-186.

In order to reconcile landscape conservation with changing demands on land use and natural resources, it is essential that the ecological, socio-cultural and economic values of the landscape be fully taken into account in planning and decision-making. This paper presents a comprehensive framework for integrated assessment of ecological services and socio-economic benefits of natural and semi-natural ecosystems and landscapes. The framework can be applied at different scale levels to different ecosystems or landscape-units and basically consists of three steps: (1) Function-analysis: translates ecological complexity into a limited number of ecosystem (or landscape) functions, which, in turn, provide a range of goods and services; (2) Function valuation: includes ecological, socio-cultural and economic valuation methods; and (3) Conflict analysis: to facilitate the application of function-analysis and valuation at different scale levels, it is important to integrate analytical valuation methods with stakeholder participation techniques.

The framework presented in this paper facilitates the structured assessment of the (total) value of the goods and services provided by a specific area (landscape) and to analyze the costs and benefits involved in trade-offs between various land use options. The last section of this paper gives some conclusions and recommendations for application-possibilities of function analysis and valuation to achieve more sustainable landscape use and maintenance of our "natural capital".

de Groot, R., M. Wilson, et al. (2002). "A typology for the classification, description and valuation of ecosystem functions, goods and services." Ecological Economics(41): 393-408.

An increasing amount of information is being collected on the ecological and socio-economic value of goods and services provided by natural and semi-natural ecosystems. However, much of this information appears scattered throughout a disciplinary academic literature, unpublished government agency reports, and across the World Wide Web. In addition, data on ecosystem goods and services often appears at incompatible scales of analysis and is classified differently by different authors. In order to make comparative ecological economic analysis possible, a standardized framework for the comprehensive assessment of ecosystem functions, goods and services is needed. In response to this challenge, this paper presents a conceptual framework and typology for describing, classifying and valuing ecosystem functions, goods and services in a clear and consistent manner. In the following analysis, a classification is given for the fullest possible range of 23 ecosystem functions that provide a much larger number of goods and services. In the second part of the paper, a checklist and matrix is provided, linking these ecosystem functions to the main ecological, socio–cultural and economic valuation methods.

Deutsch, L., C. Folke, et al. (2003). "The critical natural capital of ecosystem performance as insurance for human well-being." Ecological Economics 44: 205-217.

Complex dynamic ecosystems are important natural capital assets. We investigate how Swedish national policy has approached these assets in its work on environmental indicators. In particular, we are interested in whether or not the indicators address ecosystem performance. We discuss our inventory of Swedish indicators in the context of ecosystem services, such as source and sink functions, and the capacity of ecosystems to sustain these functions for human wellbeing. We find that effective indicators have been developed to reflect energy and material flows within society and how human activities put pressure on the environment. The part of natural capital that concerns living systems is reflected in several of the Swedish indicators in a progressive fashion, but indicators that capture the dynamic capacity of ecosystems in sustaining the flow of source and sink functions need to be further developed. We provide examples of recent developments that have started to address such indicators in the context of ecosystem resilience and environmental change, and discuss directions for their further development. We stress the importance of monitoring ecosystem resilience and performance to avoid undesirable state shifts and building ecological knowledge and understanding of this capacity into environmental indicators and their associated management institutions.

Doll, C., J. Muller, et al. (2006). "Mapping regional economic activity from night-time light satellite imagery." Ecological Economics 57: 75-92.

The recognition that the elements of the 'anthropocene' play a critical role in global change processes means that datasets describing elements of the socio-economic environment are becoming increasingly more desirable. The ability to present these data in a gridded format as opposed to the traditionally reported administrative units is advantageous for incorporation with other environmental datasets. Night-time light remote sensing data has been shown to correlate with national-level figures of Gross Domestic Product (GDP). Night-time radiance data is analysed here along with regional economic productivity data for 11 European Union countries along with the United States at a number of sub-national levels. Night-time light imagery was found to correlate with Gross Regional Product (GRP) across a range of spatial scales. Maps of economic activity at 5 km resolution were produced based on the derived relationships. To produce these maps, certain areas had to be excluded due to their anomalously high levels of economic activity for the amount of total radiance present. These areas were treated separately from other areas in the map. These results provide the first detailed examination of night-time light characteristics with respect to local economic activity and highlight issues, which should be considered when undertaking such analysis.

Ecological Society of America (2000). Ecosystem Services. Washington, Ecological Society of America: 2.

A brochure designed to introduce ecosystem services.

Ecosystem Services Project (n.d.). Natural Assets: An inventory of ecosystem goods and services in the Goulburn Broken catchment. Ecosystems Services Project, CSIRO Sustainable Ecosystems: 137.

To achieve ecological, economic and social health the Ecosystem Services Project, of which this inventory is the first step, aims to learn with communities how to deliver the right information to policy developers and decision makers in an effort to move towards more sustainable land management practices. The key findings and policy issues central to this goal are set out below, and can be found in greater detail in Chapter 6 of the report. This inventory of ecosystem services in the Goulburn Broken Catchment is a first step towards our ultimate aim. It gives an insight into what services are currently provided, and forms the basis for a more detailed assessment of what might happen to those services under a set of scenarios for the future. The inventory report sets out to achieve a number of objectives including:

- Describing the full range of goods (the things people value) produced in the Goulburn Broken Catchment.
- Identifying the dependence of these goods on various ecosystem services.
- Identifying the ecosystem services of highest priority in the Goulburn Broken for further study and management.

Ecosystem Services Project (2003). Natural values: Exploring options for enhancing ecosystem services in the Goulburn Broken catchment. Ecosystem Services Project, CSIRO Sustainable Ecosystems: 161.

Natural Values builds on the outcomes of the inventory report *Natural Assets: An Inventory of Ecosystem Goods and Services in the Goulburn Broken Catchment*. This publication identified key industries that would benefit from the preservation and investment in nature's services, laying the foundations for much of the following work. This second report presents the findings, recommendations and achievements of The Ecosystem Services Project in the Goulburn Broken Catchment. It documents theories and methods for assessing a variety of values attributable to ecosystem services under likely scenarios of catchment management in the Goulburn Broken. It discusses the implications of the results and methods in terms of catchment management, policy formulation and application of research.

Edwards-Jones, G., B. Davies, et al. (2000). Ecological economics: An introduction. Malden, Blackwell Science.

An introduction to core themes of ecological economics, specifically written for readers with no economic or philosophical training. Emphasis throughout is on complementary roles of economics, ethics, and ecology in environmental decision making processes. Reviews the evolution of important ideas in the field, explores the philosophies underlying different approaches, explains tools and techniques used in these approaches, and gives examples of how they can be applied. Examines both advantages and limitations of different analyses and how their roles vary in different contexts. Edwards-Jones teaches in the School of Agriculture and Forest Sciences at the University of Wales.

Emerton, L. and E. Bos (2004). Value: Counting ecosystems as an economic part of water. Water & Nature Initiative. Gland, International Union for Conservation of Nature and Natural Resources: 88.

This tool book reflects the growing awareness that ecosystems are important to water management. In the past, we did not realize the many benefits of ecosystems and consequently ignored them in our management decisions. The result was environmental degradation, oftentimes leading to increased poverty for water- and wetland-dependent communities. Now, we are increasingly recognizing that ecosystems play a very important role in the demand and supply side of water: ecosystems use water, regulate water supply, and provide a range of products and services on which people depend. Moreover, we increasingly have, at our disposal, the policy frameworks, the tools and the willingness to put that insight into practice. Economic valuation of ecosystem services is an important tool for effective and efficient water management as it offers us a way to make the roles of healthy ecosystems visible and to factor these into decision-making. It tells us what may be lost due to management interventions, and helps identify compensation measures. In other cases, it may lead to investments in conservation measures, such as forest management or wetland protection, and realization of sustainability of new infrastructure. Most interesting is that economic valuation may find that some investments in ecosystems lead to long-term financial or economic gain. In those cases, investments in nature deliver tangible and sustainable profits. While the usefulness of economic valuation is becoming clearer, its application is still not widespread. This tool book will help us go forward on our journey, which will end when the application of economic valuation is standard procedure in water and development decisions.

Eoma, Y. and D. Larson (2006). "Improving environmental valuation estimates through consistent use of revealed and stated preference information." Journal of Environmental Economics and Management 52: 501-516.

Environmental valuation data from stated and revealed preference methods are integrated into a unified model of preferences for environmental quality improvement that identifies the "use" and "nonuse" components of the total value estimate. This articulates clearly what parts of the total value estimate come from each type of data, and permits tests of whether estimated preferences satisfy weak complementarity between the environmental good of interest and related private goods. The statistical advantages of using more information for the valuation problem are exploited, while retaining flexibility to identify value estimates from any individual method of analysis.

Farber, S., R. Costanza, et al. (2006). "Linking ecology and economics for ecosystem management." Bioscience 56(2): 121-133.

This article outlines an approach, based on ecosystem services, for assessing the trade-offs inherent in managing humans embedded in ecological systems. Evaluating these trade-offs requires an understanding of the biophysical magnitudes of the changes in ecosystem services that result from human actions, and of the impact of these changes on human welfare. We summarize the state of the art of ecosystem services–based management and the information needs for applying it. Three case studies of Long Term Ecological Research (LTER) sites—coastal, urban, and agricultural—illustrate the usefulness, information needs, quantification possibilities, and methods for this approach. One example of the application of this approach, with rigorously established service changes and valuations taken from the literature, is used to illustrate the potential for full economic valuation of several agricultural landscape management options, including managing for water quality, biodiversity, and crop productivity.

Farber, S., R. Costanza, et al. (2002). "Economic and ecological concepts for valuing ecosystem services." Ecological Economics 41: 375-392.

The purpose of this special issue is to elucidate concepts of value and methods of valuation that will assist in guiding human decisions vis-a`-vis ecosystems. The concept of ecosystem service value can be a useful guide when distinguishing and measuring where trade-offs between society and the rest of nature are possible and where they can be made to enhance human welfare in a sustainable manner. While win-win opportunities for human activities within the environment may exist, they also appear to be increasingly scarce in a 'full' global ecological–economic system. This makes valuation all the more essential for guiding future human activity. This paper provides some history, background, and context for many of the issues addressed by the remaining papers in this special issue. Its purpose is to place both economic and ecological meanings of value, and their respective valuation methods, in a comparative context, highlighting strengths, weakness and addressing questions that arise from their integration.

Farrow, S., C. Goldburg, et al. (2000). "Economic valuation of the environment: A special issue." Environmental Science & Technology 34(8): 1384-1389.

This paper is an introduction to a set of five papers in the collection which present and illustrate the major methods used for economic valuation. Richard Carson begins the set with Contingent Valuation: A User's Guide, laying out the major assumptions and issues researchers and analysts face when implementing a contingent valuation (CV) survey for determining passive use benefits. This paper addresses the major points of controversy in CV and proposes five criteria for evaluating the quality and validity of a CV study.

Foster, J., S. Gough, et al. (n.d). Rethinking the natural capital metaphor: Implications for sustainability planning and decision-making.

The research project giving rise to this Working Paper was commissioned by the Economic and Social Research Council under its Environment and Human Behaviour New Opportunities Programme. It has comprised a series of seminars under the title "Natural Capital: Metaphor, Learning and Human Behaviour". These discussions have explored the economic metaphor of 'natural capital' in relation to human behaviour towards the environment and the prospects for achieving sustainability through changes in such behaviour. A main hypothesis emerging from the research has been that the currently dominant model of sustainable development, underpinned by a particular understanding of this metaphor, is actually impeding progress towards genuine sustainability, and will continue to do so until the metaphor can be reworked in thought and practice. The necessary reworking would have major implications for how we see the contribution of social and individual learning processes to a sustainable future, and for how we approach sustainability policy and planning. This Working Paper, one of two parallel presentations of our research findings, focuses on the second of these areas. A companion paper focuses on the first. The papers, while differing to some extent in perspective and emphasis, are essentially complementary and are intended to be read together.

Francesca, Z. and R. Herendeen (1998). Ecological numeracy: Quantitative analysis of environmental issues. New York, John Wiley & Sons.

Most environmental problems require skill in quantifying complex concepts such as energy use, waste generation, pollution production, contaminant loading, and the economic costs or benefits of regulatory action. This book is an introduction to the quantitative analysis of environmental problems, written for a broad range of environmental professionals whose quantitative skills may vary from negligible to adequate.

Freeman, M. (1991). "Valuing environmental resources under alternative management regimes." Ecological Economics 3: 247-256.

This paper shows that the economic values of resources depend in part on the management regime. The value of a resource supporting a commercial fishery will depend on whether the fishery is optimally managed or open access. The Ellis-Fisher (1987) data are used to calculate values under alternative assumptions about management. These calculations show that value is influenced not only by biological and economic factors, but also by institutions.

Gaudeta, G., M. Moreauxb, et al. (2006). "The Alberta dilemma: Optimal sharing of a water resource by an agricultural and an oil sector." Journal of Environmental Economics and Management 52: 548-566.

We fully characterize the optimal time paths of production and water usage by an agricultural and an oil sector that share a limited water resource. We show that for any given water stock, if the oil stock is sufficiently large, it will become optimal to have a phase during which the agricultural sector is inactive, followed by a phase during which both sectors are active again. The agricultural sector will always be active in the end as the oil stock is depleted. If agriculture is not constrained by the given natural inflow of water, then oil extraction will always end with a phase during which oil production follows a pure Hotelling path. Otherwise, oil production never follows a pure Hotelling path, because its full marginal cost must always reflect not only the imputed rent on the finite oil stock, but also the positive opportunity cost of water usage. The case of oil and agriculture sharing a water resource is but one example. Our analysis provides a framework to generalize the Hotelling rule to other cases where the full marginal opportunity cost of extracting a nonrenewable resource depends on the endogenous activity of some other sector of the economy.

Gossling, S. (1999). "Ecotourism: A means to safeguard biodiversity and ecosystem functions?" Ecological Economics 29: 303-320.

This paper argues that, at present, ecotourism can contribute to safeguard biodiversity and ecosystem functions in developing countries, even though meeting the requirements for ecotourism is extremely difficult. A cost-benefit analysis of those ecosystems richest in species diversity, i.e. tropical rainforests, leads to the conclusion that non-use values often outweigh the values of conventional uses (clear-cutting, pasture, etc.), but are hardly considered in development decisions. Therefore, tourism and its high direct use value can play an important role as an incentive for protection. As tourism causes significant emissions, e.g. by flying, the concept of Environmental Damage Costs is introduced and integrated into the calculations. Further, international tourism development is analyzed and related to protection goals. Visitation rates of sensitive areas need to be limited; education, management, and control measures have to be integrated; and the proportion of money captured from tourists has to be increased. In the long run, tourism needs to undergo substantial changes.

Government of Alberta (2003). Water for life: Alberta's strategy for sustainability. Water for Life. Edmonton, Government of Alberta: 32.

Water for Life: Alberta's Strategy for Sustainability is the Government of Alberta's response to develop a new water management approach and outline specific strategies and actions to address these issues.

Government of Alberta (2005). Report on implementation progress of water for life: Alberta's sustainability strategy. Water for Life. Edmonton, Government of Alberta: 56.

The Government of Alberta is committed to the wise management of Alberta's water for the benefit of Albertans now and in the future. Water for Life outlines specific strategies and actions to achieve three goals:

- Safe, secure drinking water supply
- Healthy aquatic ecosystems
- Reliable, quality water supplies for a sustainable economy

In order to fulfill the goals of the strategy, the actions outlined in the Water for Life strategy revolve around three key directions:

- Knowledge and research
- Partnerships
- Water conservation

Gutman, P. (2005). Payments for ecosystem services: Basic concepts and outstanding issues. Sophia, Bulgaria, World Wildlife Fund.

This document is a presentation made at a World Wildlife Fund workshop in Sophia, Bulgaria. Gutman considers the prospects of payments for ecosystem services (PES) in Europe and the NIS.

Hansson, C. and M. Wackernagel (1999). "Rediscovering place and accounting space: How to re-embed the human economy." Ecological Economics 29: 203-213.

This article proposes to move beyond monetary assessments of ecosystem services in order to counteract an important mechanism behind their current undervaluation: the process of disembedding. Disembedding describes the influence of modernity on social relationships. It also clarifies how Human-Nature relationships have been affected. Modern societies have become disembedded from the context of local ecosystems, resulting in diminishing knowledge of, and attention to, ecosystem services. The emergence of general purpose money is presented as a key factor in the disembedding process because it has brought with it the message of substitutability and the possibility of an increasing appropriation of distant ecosystems. The paper argues that, in order to re-embed societies instead of pursuing current trends, the limits to human expansion in the biosphere have to be made visible. Therefore, a strategy of re-embedding the human economy into the life-support context is put forward, where bioregional thought and its intention of rediscovering, mapping, and 're-inhabiting' local places is combined with the ecological footprint tool. In contrast to monetary assessments of ecosystem services, the ecological footprint assessment presents the limits of the services' availability, and thus clarifies the fact that increased appropriation of bio-productive space normally involves increasing pressure on remaining ecosystems.

Havstad, K., D. Peters, et al. (2007). "Ecological services to and from rangelands of the United States" Ecological Economics (in press): 9.

The over 300 million ha of public and private rangelands in the United States are characterized by low and variable precipitation, nutrient-poor soils, and high spatial and temporal variability in plant production. This land type has provided a variety of goods and services, with the provisioning of food and fiber dominating through much of the 20th century. More recently, food production from a rangeland-based livestock industry is often pressured for a variety of reasons, including poor economic returns, increased regulations, an aging rural population, and increasingly diverse interests of land owners. A shift to other provisioning, regulating, cultural, and supporting services is occurring with important implications for carbon sequestration, biodiversity, and conservation incentives. There are numerous goods and services possible from rangelands that can supply societal demands such as clean water and a safe food supply. The use of ecologically based principles of land management remains at the core of the ability of private land owners and public land managers to provide these existing and emerging services. We suggest that expectations need to be based on a thorough understanding of the diverse potentials of these lands and their inherent limits. A critical provisioning service to rangelands will be management practices that either maintain ecological functions or that restores functions to systems that have been substantially degraded over past decades. With proper incentives and economic benefits, rangelands, in the U.S. or globally, can be expected to provide these historical and more unique goods and services in a sustainable fashion, albeit in different proportions than in the past.

Hawkins, K. (2003). Economic valuation of ecosystem services, University of Minnesota: 43.

This paper aims to summarize the current knowledge about ecosystem services and their valuation. It is organized in two sections, the first regarding ecosystem services. It will attempt to find a definition for ecosystem services. This will be followed by a classification, listing, and description of specific services. The classification and description will be on a broad, global level, so it will be followed by a description of ecosystems and the services that are relevant to southeastern Minnesota. Finally, the section will conclude with a discussion about how and why we are losing services. The second section discusses the valuation of ecosystem services, starting off by describing the different values economists apply to ecosystems. Next is a discussion of the methods used in valuation, followed by examples of valuation studies, specific to Minnesota or the Midwest when possible. Finally, the paper will end by describing some of the issues and limitations of ecosystem service valuation.

Hay, P. (2002). Main currents in western environmental thought. Bloomington, Indiana University Press.

In his Chapter 8 on economic thought and the environment, Hay clearly distinguishes ecological economics from environmental economics, and devotes more space to discussing the former, including the contributions of many individual ecological economists.

Heal, G. (2000). Nature and the marketplace: Capturing the value of ecosystem services. Washington, Island Press.

In recent years, scientists have begun to focus on the idea that healthy, functioning ecosystems provide essential services to human populations, ranging from water purification to food and medicine to climate regulation. Lacking a healthy environment, these services would have to be provided through mechanical means, at a tremendous economic and social cost. Nature and the Marketplace examines the controversial proposition that markets should be designed to capture the value of those services. Written by an economist with a background in business, it evaluates the real prospects for various of nature's marketable services to "turn profits" at levels that exceed the profits expected from alternative, ecologically destructive, business activities. The author: describes the infrastructure that natural systems provide, how we depend on it, and how we are affecting it explains the market mechanism and how it can lead to more efficient resource use looks at key economic activities-such as ecotourism, bioprospecting, and carbon sequestration-where market forces can provide incentives for conservation examines policy options other than the market, such as pollution credits and mitigation banking considers the issue of sustainability and equity between generations . Nature and the Marketplace presents an accessible introduction to the concept of ecosystem services and the economics of the environment. It offers a clear assessment of how market approaches can be used to protect the environment, and illustrates that with a number of cases in which the value of ecosystems has actually been captured by markets. The book offers a straightforward business economic analysis of conservation issues, eschewing romantic notions about ecosystem preservation in favor of real-world economic solutions. It will be an eye-opening work for professionals, students, and scholars in conservation biology, ecology, environmental economics, environmental policy, and related fields.

Heal, G. (2000). "Valuing ecosystem services." Ecosystems 3: 24-30.

In this article Heal notes that the emphasis on valuing ecosystems and their services is probably misplaced. Economics cannot estimate the importance of natural environments to society: only biology can do that. The role of economics is to help design institutions that will provide incentives for the conservation of important Valuing Ecosystem Services 29 natural systems and will mediate human impacts on the biosphere so that these are sustainable.

Heal, G., G. Daily, et al. (2001). "Protecting natural capital through ecosystem service districts." Stanford Environmental Law Journal 20: 333–364.

In this article we use ecological, economic, and legal analyses to create a conceptual framework for managing patterns of land use in districts of varying sizes that could provide different ecosystem services and also support different, and potentially conflicting, types of economic activity. Part II of the article explains why ecosystem services are under threat and describes the potential benefits of managing their conservation through ESDs. Part III lays out the basic ecological-economic framework and principles for district design. Part IV sets out the key legal issues involved in the creation and management of ESDs, and Part V presents a roadmap for putting theory into practice.

Hein, L., K. van Koppen, et al. (2006). "Spatial scales, stakeholders and the valuation of ecosystem services." Ecological Economics (57): 209-228.

Since the late 1960s, the valuation of ecosystem services has received ample attention in scientific literature. However, to date, there has been relatively little elaboration of the various spatial and temporal scales at which ecosystem services are supplied. This paper analyzes the spatial scales of ecosystem services, and it examines how stakeholders at different spatial scales attach different values to ecosystem services. The paper first establishes an enhanced framework for the valuation of ecosystem services, with specific attention for stakeholders. The framework includes a procedure to assess the value of regulation services that avoids double counting of these services. Subsequently, the paper analyses the spatial scales of ecosystem services: the ecological scales at which ecosystem services are generated, and the institutional scales at which stakeholders benefit from ecosystem services. On the basis of the proposed valuation framework, we value four selected ecosystem services supplied by the De Wieden wetlands in The Netherlands, and we analyze how these services accrue to stakeholders at different institutional scales. These services are the provision of reed for cutting, the provision of fish, recreation, and nature conservation. In the De Wieden wetland, reed cutting and fisheries are only important at the municipal scale, recreation is most relevant at the municipal and provincial scale, and nature conservation is important in particular at the national and international level. Our analysis shows that stakeholders at different spatial scales can have very different interests in ecosystem services, and we argue that it is highly important to consider the scales of ecosystem services when valuation of services is applied to support the formulation or implementation of ecosystem management plans.

Helliwell, D. (1969). "Valuation of wildlife resources." Regional Studies 3: 41-47.

The recognizable benefits afforded by wildlife are listed as production, potential production, education, and recreation. These are further divided into a total of seven categories for the purpose of evaluation. Conventional cost-benefit analysis is regarded as being too tedious and difficult a process to be widely and frequently used. An attempt is made, therefore, to give a system for comparing one wildlife resource with another; the whole system being correlated to monetary values at a later stage. The principal parameters of assessment are the scarcity of the resource, its accessibility, and the diversity of species within it. Each of the seven categories of benefit is dealt with separately, to give a total for the resource as a whole.

Higgins, S., J. Turpie, et al. (1997). "An ecological economic simulation model of mountain fynbos ecosystems: Dynamics, valuation and management." Ecological Economics 22: 155-169.

This paper develops an ecological-economic argument for the effective management of plant invasions in mountain fynbos ecosystems. This is done through the creation of dynamic ecological economic model which values the ecosystem services that fynbos ecosystems provide.

Holmlund and M. Hammer (1999). "Ecosystem services generated by fish populations." Ecological Economics 29: 253-268.

In this paper, we review the role of fish populations in generating ecosystem services based on documented ecological functions and human demands of fish. The ongoing overexploitation of global fish resources concerns our societies, not only in terms of decreasing fish populations important for consumption and recreational activities. Rather, a number of ecosystem services generated by fish populations are also at risk, with consequences for biodiversity, ecosystem functioning, and ultimately human welfare. Examples are provided from marine and freshwater ecosystems, in various parts of the world, and include all life-stages of fish. Ecosystem services are here defined as fundamental services for maintaining ecosystem functioning and resilience, or demand-derived services based on human values. To secure the generation of ecosystem services from fish populations, management approaches need to address the fact that fish are embedded in ecosystems and that substitutions for declining populations and habitat losses, such as fish stocking and nature reserves, rarely replace losses of all services.

Howarth, R. and S. Farber (2001). "Accounting for the value of ecosystem services." Ecological Economics 41: 421-429.

A 'value of ecosystem services' (VES) may be calculated by multiplying a set of ecosystem services by a set of corresponding shadow prices. This paper examines the role of the VES concept in measuring trends in human wellbeing. Under conventional arguments from applied welfare economics, standard measures of market consumption may be extended to include the value of direct environmental services, which affect welfare in ways that are not mediated by the consumption of purchased goods. The VES concept does not capture values such as ecological sustainability and distributional fairness that are not reducible to individual welfare. And its operationalization is constrained by the well-known limitations of nonmarket valuation methods. Nonetheless, attempts to calculate the value of environmental services can provide insights into the tradeoffs between market activity and environmental quality that are implicit in the process of economic growth. Such efforts can promote informed debate concerning the achievement of sustainable development.

Hussen, A. (1991). Principles of environmental economics: Economics, ecology and public policy New York, Routledge.

With international case studies and examples, this book will prove an excellent choice for introducing both students and other academics to the world of environmental economics.

Ingraham, M. and S. Foster (2005). The indirect use value of ecosystem services provided by the United States National Wildlife Refuge System, Graduate Program in Sustainable Development and Conservation Biology University of Maryland, College Park: 20.

The objective of this study was to estimate the economic value, in real (2004) dollars, of the ecosystem services provided by the National Wildlife Refuge System. This study concentrated solely on the indirect use value of ecosystem services within the contiguous United States. Direct use values provide outputs such as fish or recreation. Indirect use values, or functional values, provide benefits such as flood control, nutrient/sediment trapping and nursery or habitat services (Barbier, 2000). In order to calculate this value, we determined the ecosystems present on Refuge System lands, the proportion in which they are represented, and the dollar value of services provided by each. We used land cover classes as an approximation of ecosystems present in the Refuge System. In a geographic information system (GIS), we combined land cover geospatial data with an interactive map of the Refuge System boundaries (Dietz, 2003; USFWS, 2001; USGS, 2004; Vogelmann et al., 2001) to calculate the number of acres for each refuge and land cover class within the Refuge System. We transferred values for the following ecosystem services: climate and atmospheric gas regulation; disturbance prevention; freshwater regulation and supply; waste assimilation and nutrient regulation; and habitat refugium. We conducted a central tendency value transfer by transferring averaged values, taken from primarily original site studies, to the Refuge System based on the ecoregion in which each site study and refuge was located and their relative net primary productivity (NPP). The methodologies used in the site studies include valuation techniques such as direct market valuation, indirect market valuation and contingent valuation. We calculated the total indirect use value of ecosystem services provided by National Wildlife Refuge System lands in the contiguous U.S. to be $29.8 billion/year. Data limitations identified in this study present several compelling opportunities for future research.

Jansson, A., M. Hammer, et al., Eds. (1994). Investing in natural capital: The ecological economics approach to sustainability Washington, Island Press.

Investing in Natural Capital presents the results of a workshop held following the second biannual conference of the International Society for Ecological Economics. It focuses on the relation of human development to natural capital, and the relation of natural capital to environmental processes. Because we are capable of understanding our impact on the environment and the importance of managing it sustainably, humans play a special role in our ecosystem. The book emphasizes the essential connections between natural ecosystems and human socioeconomic systems, and the importance of insuring that both remain resilient. Specific chapters deal with methodology, case material, and policy questions, and offer a thorough exploration of this provocative and important alternative to conventional economics.

Kopp, R., W. Pommerehne, et al., Eds. (1997). Determining the value of non-marketed goods: Economic, psychological, and policy relevant aspects of contingent valuation methods. Norwell, Springer.

Contingent valuation (CV) measures what is called passive use value or existence value. The CV method has been used to measure the benefits of environmental policy actions. CV measures of economic value rely on choice. In CV studies, choices are posed to people in surveys; analysts then use the responses to these choice questions to construct monetary measures of value. The specific mechanism used to elicit respondents' choices can take a variety of forms, including asking survey respondents whether they would purchase, vote, or pay for a program or some other well-defined object of choice. It can also be a direct elicitation of the amount each respondent would be willing to pay (WTP) to obtain an object of choice or the amount each respondent would be willing to accept (WTA) in compensation to give it up. This volume is composed of three sections. The first section provides background into the issues underlying the public and academic discussion regarding CV and the reliability of CV estimates of economic value. In addition, this section reviews the theory underlying the measurement of economic value and discusses those aspects of the theory most relevant to CV. The second section focuses on issues that have formed the core of the CV discussions including: sensitivity of WTP estimates to the size of the program offered, tests for theoretical consistency of CV results, and the sensitivity of results to context and numerous other features of the survey and its administration. The final section addresses the application of CV to actual economic valuation tasks and discusses the types of practical problems the CV researcher will encounter.

Krishnan, R., J. Harris, et al., Eds. (1995). A survey of ecological economics Frontier Issues in Economic Thought. Washington, Island Press.

The emergent discipline of ecological economics is based on the idea that the world's economies are a function of the earth's ecosystems – an idea that radically reverses the world view of neoclassical economics. A Survey of Ecological Economics provides the first overview of this new field, and a comprehensive and systematic survey of its critical literature. The editors of the volume summarize ninety-five seminal articles, selected through an exhaustive survey, that advance the field of ecological economics and represent the best thinking to date in the area. Each two- to three-page summary is far more comprehensive than a typical abstract, and presents both the topics covered in each paper and the most important arguments made about each topic. Sections cover: historical perspective definition, scope, and interdisciplinary issues theoretical frameworks and techniques energy and resource flow analysis accounting and evaluation North-South/international issues ethical/social/institutional issues Each section is preceded by an introductory essay that outlines the current state of knowledge in the field and proposes a research agenda for the future.

Kumar, P. (2005). Market for Ecosystem Services. Winnipeg, International Institute for Sustainable Development (IISD): 32.

Review of valuation studies suggest that the total value of direct ecosystem service payments in tropical countries is presently modest, but has grown dramatically over the past decade and is significant, particularly to low-income producers. Markets for forest ecosystem services are expected to grow, in both developed and developing countries, over the next 20 years. Governments play a critical role as the principal buyers of many ecosystem services and as catalysts for many private-sector direct-payment schemes. Without constructive intervention through enabling conditions, monitoring institutions and adequate governance, the market, even though based on very accurate valuation methods, is a recipe for disaster. It should not be forgotten that payments for ecosystem services will, in most cases, cover only a modest share of the total costs of good ecosystem management. However the payment for ecosystem services could prove to be a catalyst in the future.

Lee, P., D. Aksenov, et al. (2006). Canada's large intact forest landscapes. Edmonton, Global Forest Watch Canada: 84.

This report is a refinement and update of a preliminary analysis of the ecological integrity of Canada's forests, which was released in 2003 under the name "Canada's Large Intact Forest Landscapes." Canada's forests provide critically important benefits to the nation — ranging from their economic contributions via the forest products industry to recreational opportunities to life-sustaining ecosystem services, such as soil erosion control and watershed protection. This project to map Canada's intact forest landscapes aims to increase knowledge about their extent and location, and to enable better decision-making by providing data in accessible forms for use by government, industry, and the public. The project builds on and extends previous work assessing forest intactness in Canada and is part of a larger effort by the Global Forest Watch network to map intact forest landscapes in important forest countries around the world. The methodology was initially developed by Global Forest Watch to map Russia's intact forest landscapes, and analysts from Global Forest Watch Russia have been key partners in this Canadian study.

Levitt, J., Ed. (2005). From Walden to Wall Street: frontiers of conservation finance. Washington, Island Press.

From Walden to Wall Street makes clear that a system of market-based conservation finance is vital to the future of environmental conservation. In the absence of innovation in the field of conservation finance, a daunting funding gap faces conservationists aiming to protect America's system of landscapes that provide sustainable resources, water, wildlife habitat, and recreational amenities. Experts estimate that the average annual funding gap will be between $1.9 billion and $7.7 billion over the next forty years. Can the conservation community come up with new methods for financing that will fill this enormous gap? Which human and financial resources will allow us to fund critical land conservation needs? Contributors present groundbreaking ideas including mainstreaming environmental markets; government ballot measures for land conservations; convertible tax-exempt financing; and private equity markets.

Limburg, K. and C. Folke (1999). "The ecology of ecosystem services: Introduction to the special issue." Ecological Economics 29: 179-182.

This editorial provides an introduction to this special issue, consisting of eight papers which reflect the diversity of backgrounds and interests from which the authors approach the subject of the ecology of ecosystem services.

Limburg, K., R. O'Neill, et al. (2002). "Complex systems and valuation." Ecological Economics 41: 409-420.

Ecological and economic systems are undeniably complex. Whereas a goal of delineating 'ecosystem services' is to make readily apparent some of the important ways in which ecosystems underpin human welfare, insights are also gained by appreciating the nonlinear dynamic properties of ecosystems. In this paper, we review some of the relevant characteristics of complex systems. Ecosystems and economic systems share many properties, but valuation has typically been driven by short-term human preferences. Here we argue that as the force of humanity increases on the planet, ecosystem service valuation will need to switch from choosing among resources to valuing the avoidance of catastrophic ecosystem change.

Lockwood, M. (1997). "Integrated value theory for natural areas." Ecological Economics 20: 83-93.

Value assessment is a necessary component of any rational decision-making process concerning the use or management of natural areas. This paper describes an integrated value theory for identifying, measuring and aggregating human values for natural areas. To ensure philosophical coherence, the framework makes a commitment to a specific theory of end values. Three related levels of end value are identified, which give meaning to the values expressed by humans. The theory addresses the three rational modes of human value expression: weakly comparable, noncompensatory and exchange. Exchange value expressions are consistent with neoclassical economic notions of value. The other types of value expression are not. Current techniques for aggregating values include multicriteria analysis and benefit cost analysis. Multicriteria analysis can encompass the three modes of value expression, but does not readily discriminate between them, and so fails to take advantage of the full information content of noncompensatory and exchange preferences. Benefit cost analysis, on the other hand, assumes a particular structure of values which means it should be limited to assessment of exchange preferences. The framework outlined in this paper provides an advance on both of these methods, in that it combines the specificity of benefit cost analysis with the breadth of multicriteria analysis.

Ludwig, D. (2000). "Limitations of economic valuation of ecosystems." Ecosystems 3: 31-35.

Valuation methods have been prominent in recent discussions because they are being used in legal efforts to protect and restore ecosystems (Portney1994). Such methods also seem to be a promising way to include ecological values when various public policies and projects are under consideration. Economic valuations may have quite perverse and pernicious effects unless they are applied with a careful regard for their limitations. I believe that, in fact, the proper domain of application of such methods is quite limited. Such methods work well for small projects of minor importance, or possibly for fine-tuning of larger projects. But these methods— and economic methods in general—are inappropriate and harmful when used to determine important public policies.

My main objections to valuation are:

1. Economic values are generally of tertiary importance: personal and social values are of a higher order and are generally incompatible with economic values.
2. Economic theories require a host of simplifying assumptions that have dubious validity. The effect of these simplifications is seldom if ever assessed.
3. Market measures or survey measures are inappropriate for decisions that involve important ecological questions.
4. The methods customarily used for valuation of ecosystems have such severe internal flaws that the results have little significance.

After considering each of these points in more detail, I offer a few hints for the wary who may be about to cooperate in a valuation exercise.

Matthews, E., R. Payne, et al. (2000). Pilot analysis of global ecosystems: Forest ecosystems. Washington, World Resources Institute: 86.

Provides a "big picture" view of forest extent and change and the role of these ecosystems in industrial roundwood production, woodfuel use and availability, biodiversity, carbon storage and sequestration, and watershed protection. Forests ecosystems examines the spatial extent of forests and the degree of human modifications on their extent and structure over time. It also looks at measures of condition concerning five important goods and services: industrial roundwood and woodfuel production, biodiversity, carbon storage and sequestration, and watershed protection. The choice of goods and services was determined partly in consultation with forestry experts in many countries and partly by data availability. Results of the analysis show that global forest cover has been reduced by between 20 and 50 percent since preagricultural times.

McCarthy, J., O. Canziani, et al., Eds. (2001). Climate change 2001: impacts, adaptation, and vulnerability. Cambridge, Cambridge University Press.

Brings us completely up-to-date on the vulnerability of socio-economic and natural systems to climate change. Could enhanced global warming increase agricultural productivity and open new areas for farming? Might small changes in water runoff drastically disrupt major rivers and dramatically extend infectious disease vectors in Africa? With many species of plants and animals on the verge of extinction, the ecosystem of an entire continent may be at stake due to global warming. On the plus side, available evidence is offered showing possible enhanced productivity in forests and fields under optimal conditions. Precipitation variations affecting ground water recharge are creating drought and famine in dry areas, while buried hazardous waste is forced to the surface in newly wet areas. The melting of tropical glaciers in Asia, Latin America, and Africa is one of the most devastating and irreversible impacts of global warming cited in this authoritative and inclusive reference volume. This latest assessment of the Intergovernmental Panel on Climate Change conveniently cites and indexes the latest findings in a useful and attractive package that will stimulate research and convince skeptics.

McGlade, J., Ed. (1998). Advanced ecological theory: Principles and applications. Malden, Blackwell Publishing.

Advanced Ecological Theory is intended for both postgraduate students and professional researchers in ecology. It provides an overview of current advances in the field as well as closely related areas in evolution, ecological economics and natural resource management, familiarizing the reader with the mathematical, computational and statistical approaches used in thee different areas. The book has an exciting set of diverse contributions written by leading authorities.

Millennium Ecosystem Assessment (2005). Ecosystems and human well-being: Synthesis Washington, World Resources Institute.

This report presents a synthesis and integration of the findings of the four MA working groups (Conditions and Trends, Scenarios, Responses, and Sub-global Assessments). It does not, however, provide a summary of each working group report. This synthesis is organized around the core questions originally posed to the assessment: How have ecosystems and their services changed? What has caused these changes? How have these changes affected human well-being? How might ecosystems change in the future and what are the implications for human well-being? And what options exist to enhance the conservation of ecosystems and their contribution to human well-being?

Millennium Ecosystem Assessment (2005). Living beyond our means: Natural assets and human well-being. Statement from the Board. Millennium Ecosystem Assessment: 28.

This statement is from the Board governing the MA process, whose membership includes representatives from U.N. organizations, governments through a number of international conventions, nongovernmental organizations, academia, business, and indigenous peoples. It is not intended as a comprehensive summary of the findings of the MA, but rather as an interpretation of the key messages to emerge from it. Written for a non-specialist readership, it is nevertheless consistent with the more detailed documents of the assessment and can be read in conjunction with them.

Moberg, F. and C. Folke (1999). "Ecological goods and services of coral reef ecosystems." Ecological Economics 29: 215-233.

This article identifies ecological goods and services of coral reef ecosystems, with special emphasis on how they are generated. Goods are divided into renewable resources and reef mining. Ecological services are classified into physical structure services, biotic services, biogeochemical services, information services, and social/cultural services. A review of economic valuation studies reveals that only a few of the goods and services of reefs have been captured. We synthesize current understanding of the relationships between ecological services and functional groups of species and biological communities of coral reefs in different regions of the world. The consequences of human impacts on coral reefs are also discussed, including loss of resilience, or buffer capacity. Such loss may impair the capacity for recovery of coral reefs and as a consequence the quality and quantity of their delivery of ecological goods and services. Conserving the capacity of reefs to generate essential services requires that they are managed as components of a larger seascape-landscape of which human activities are seen as integrated parts.

Murtough, G., B. Aretino, et al. (2002). Creating markets for ecosystem services. Productivity Commission Staff Research Paper. Canberra, Commonwealth of Australia: 79.

This paper investigates how well environmental problems related to salinity, biodiversity and climate change can be addressed by creating markets for ecosystem services.

Nadeau, R. (2003). The wealth of nature: How mainstream economics has failed the environment. New York, Columbia University Press.

Although economics may still be described colloquially as the "dismal science," Nadeau argues that the propounders of classical and neoclassical economic theory, from Adam Smith in the 18th century to the present, have been mistaken in asserting that economics is a science. Through careful textual analysis, the author explains how economists, using outmoded metaphysical assumptions originally propounded by Smith in The Wealth of Nations, deceived themselves into believing that there are natural laws of economics. Furthermore, these misjudgments were compounded in the 19th century by the use of now discredited mathematical formulas, in which economic forces were perceived by economists in the same way physicists perceived principles of physics. The title of this book is an ironic play on the title of Smith's seminal explanation of capitalism. Unfortunately, the author contends, the continuing formalistic misapprehensions of economists spell possible global environmental catastrophes. These dislocations will result from outdated economic theories that do not take into account the physical realities of the world. The writer proposes a reordering of economic studies that will include an awareness of the vital interplay between ecology, natural resources, trade and population. This well-annotated, scholarly treatment of a dense subject is written in a lively style and will appeal largely to serious students of economics, history, ecology and philosophy.

National Research Council of the National Academies (2004). Valuing ecosystem services: Toward better environmental decision-making. Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems. Washington: 249.

This paper evaluates methods for assessing services and the associated economic values of aquatic and related terrestrial ecosystems. The work focuses on identifying and assessing existing economic methods to quantitatively determine the intrinsic value of these ecosystems in support of improved environmental decision-making, including situations where ecosystem services can only be partially valued.

National Round Table on the Environment and the Economy (2003). Securing Canada's natural capital: A vision for nature conservation in the 21st century. Ottawa, National Round Table on the Environment and the Economy.

The Round Table has developed a strategic framework for action, and believes that this framework must be implemented in order to achieve more and better conservation in Canada. The framework features five core elements: 1) design conservation solutions through integrated planning, by focusing on planning that looks at whole landscapes and considers the social, economic and environmental values of those landscapes; 2) level the playing field for conservation, by encouraging industry to become a better steward of Canada's lands and seas; 3) enhance stewardship by all Canadians, to encourage and support local communities in conservation planning and monitoring; 4) build and share a strong base of knowledge in support of conservation in Canada; and 5) value natural capital, to ensure that economic decisions formally factor in the value of nature. The report examines the application of these core elements in four specific areas: 1) conservation planning for whole landscapes, 2) working with industry to promote whole-landscape approaches, 3) community stewardship and 4) marine ecosystems. Each of these areas represents unique and important opportunities to advance conservation on the ground and accelerate implementation of the Round Table's vision.

Nature (1998). "Audacious bid to value the planet whips up a storm." Nature 395: 430.

This article is a commentary on Costanza et al's 1997 attempt to place a monetary value on ecosystem services and natural capital.

Newcome, J., A. Provins, et al. (2005). The economic, social and ecological value of ecosystem services: A literature review. London, The Department for Environment, Food and Rural Affairs: 47.

This report presents the results of a broad review of the literature that has investigated the economic and other values of ecosystem goods and services. The review was commissioned by DEFRA (UK Department of Environment, Food and Rural Affairs) to examine the role of ecosystem goods and services in communicating the benefits of biodiversity. The report considers the contribution of such goods and services from socio-economic and ecological perspectives drawing upon mostly international examples, and focusing on wetlands, forests and agro-ecosystems. Two case studies are presented in Annex 1 to demonstrate how ecosystem goods and services can be defined and their value quantified. Annex 2 contains a technical report that presents the scope of the study and further details on the issues discussed in the main report.

Norberg, J. (1999). "Linking nature's services to ecosystems: Some general ecological concepts." Ecological Economics 29: 183-202.

I present a selected review of ecological concepts that are important for understanding how nature's services are linked to their support system, the ecosystem. The paper is mainly aimed at an audience of non-biologists to facilitate cooperation among disciplines. A list of services compiled from the literature is classified according to ecological criteria that relate to the properties of the services. These criteria are: (1) if the goods or services are produced and maintained within the ecosystem or shared with other ecosystems; (2) if the goods or object of the service are living or inorganic material; and (3) what biological unit is associated with production and maintenance, i.e. an individual, a species, a group of species, an entire community, the ecosystem, the landscape or on a global scale. Using these criteria I have identified and selected three major groups of ecosystem services for which some common ecological concepts apply. These are: (1) the maintenance of populations; (2) the use of ecosystems as filters of externally imposed compounds; and (3) the property of biological units to create organization through selective processes. These three categories are examined and exemplified in detail.

O'Connor, M. and C. Spash, Eds. (1999). Valuation and the environment: Theory, method, and practice. Advances in Ecological Economics. Cheltenham, Edward Elgar Publishing.

This book presents recent advances in the theory and practice of environmental valuation and resource management. Leading experts in the field present methodological and empirical evidence for applying valuation methods to ecological policy problems. The methodological contributions examine such themes as uncertainty, distributional conflict, positional analysis, weak comparability and the need for collective solutions to environmental problems. Case studies are incorporated to support these theoretical reflections. A number of empirical studies are used to demonstrate and evaluate valuation practices in a variety of institutional and policy settings. These range from international environmental issues such as climate change and transboundary atmospheric pollution, to species preservation and coastal ecosystem protection. The contributors conclude that effective and appropriate approaches for evaluation of environmental risks, degradation and benefits must be specifically designed as a function of institutional social and ecological factors. Valuation and the Environment will be essential reading for students and scholars of environmental and ecological economics, environmental management and regulation, resource management and public policy.

Odum, E. and H. Odum (1972). Natural areas as necessary components of man's total environment. Transactions of the 37th North American Wildlife and Natural Resources Conference, Washington, Wildlife Management Institute.

Odum, H. and E. Odum (2000). "The energetic basis for valuation of ecosystem services." Ecosystems 3: 21-23.

Odum provides a commentary of ecosystem valuation in which he concludes that timing is of the essence. After several decades of theoretical discussions and many real-world applications, we judge that the time has come for serious consideration of the energetic approach to valuation of ecosystem services and market goods and services on a common basis. We need not only to extend market valuations to include more consideration of ecosystem services, but ultimately we need to put the economy on the same basis as the work of the environment (that is, externalize the internalities).

Olewiler, N. (2004). The value of natural capital in settled areas of Canada, Ducks Unlimited and The Nature Conservancy of Canada 36.

This paper illustrates the services provided by, and the importance of valuing, natural capital in the settled areas of Canada. Destruction and degradation of natural capital occurs continually across Canada. Yet, we may not recognize the full value of these losses until it is too late. Case studies in this paper illustrate that governments may be making inefficient choices in allocating land to uses that destroy or degrade natural capital. For example, protecting the existing natural capital in the Lower Fraser Valley may save society hundreds of millions, if not billions of dollars every year. Yet, natural capital continues to be destroyed in this area. The agriculture lands case studies revealed that the estimated net value of conserving or restoring natural areas is about $195/ha/yr in the Grand River Watershed of Ontario, about $65/ha/yr in the Upper Assiniboine River Basin in eastern Saskatchewan and western Manitoba, and about $126/ha/yr in the Mill River Watershed in P.E.I. These case studies reinforce that ignoring the value of natural capital when making decisions about land use will likely result in the degradation and destruction of natural capital and lead to outcomes that are very costly to society both now and into the future. This paper does not propose specific policies or programs for the protection of natural capital; rather, it identifies that governments have the following important roles to play.

Organisation for Economic Co-operation and Development (2001). Valuation of biodiversity studies: Selected studies. Environment. Paris, Organisation for Economic Co-operation and Development: 181.

The compendium is organised in four parts. Part 1 introduces the concepts of biodiversity and biological resources and discusses how to quantify the value associated with changes in the level or quality of global environmental services at the local and national levels. Part 2 looks at the application of economic valuation of environmental policy in the United States and Europe and discusses some of the reasons why evaluation techniques are not more widely used. In particular, the main issues in benefit transfer - the transfer of values found in the literature to a new policy site - are discussed. Part 3 and 4 examine some alternative methodological approaches to the valuation of biodiversity: conjoint analysis and the development of an ecological indicator (i.e. non-monetary) of ecosystem value. Part 4 also provides an initial attempt to integrate economic and ecological valuation.

Palmer, M., E. Bernhardt, et al. (2004). "Ecology for a Crowded Planet." Science 304(5675).

Ecological science has been important in improving human life, and research addressing the sustainability and resilience of socioecological systems has begun. Elsewhere, we discuss partnerships and programs that are required. Here, we recommend a research agenda centered on ecosystem services and the science of ecological restoration and design.

Palmer, M., E. Bernhardt, et al. (2004). 21st century vision and action plan for the ecological society of America. Report from the Ecological Visions Committee to the Governing Board of the Ecological Society of America, Ecological Science and Sustainability for a Crowded Planet.

Environmental issues will define the 21st Century, as will a world with a large human population and ecosystems that are increasingly shaped by human intervention. New partnerships and large-scale, cross-cutting activities will be key to incorporating ecological solutions in sustainability. We recommend a four-pronged research initiative, to be built on new and existing programs, to enhance research project development, facilitate large-scale experiments and data collection, and link science to solutions. We emphasize the need to improve interactions among researchers, managers, and decision makers. Building public understanding of the links between ecosystem services and human well-being is essential. We urge the development of a major public information campaign to bring issues and raise awareness of ecological sustainability before the general public. Specific recommendations for each visionary area will support rapid progress. Standardization of data collection, data documentation, and data sharing is long overdue and should be kick-started through a data registry, easy access to metadata, and graduate and professional training of ecologists in ecoinformatics. A rapid response team that draws on ecological expertise in responding to legislative and executive branch proposals would result in a larger role for ecological knowledge and ecological scientists in the legislative and policy processes that impact sustainability. We must develop resources that will help ecologists and collaborators from other sciences work together more effectively. A meeting of key leaders in research, management, and business should be convened to produce a plan to create reward systems for ecological researchers and educators, as well as to foster collaborations. We need more global access to ecological knowledge. This effort could be started through routine translation of key ecological articles from non-English to English and vice versa. In addition, strategies to ease the exchange of students, managers and practitioners among institutions in various countries should be implemented. The three visionary areas and the recommendations to achieve them will provide a framework for advancing ecological research and ensuring it plays a key role in public and private discourse. The most critical vision area is the first: building an informed public. The results of simultaneously addressing our recommendations for the three visionary areas will be an ecological science marked by strong regional and global partnerships that will be instrumental in the move toward a more sustainable future for ecosystems and the humans they support.

Pearce, D. (2001). "The economic value of forest ecosystems." Ecosystem Health 7(4): 284-296.

This paper surveys what we know about forest economic values and draws policy conclusions from the now substantial literature that values nonmarket benefits of forests. Estimating economic values is not enough. The subsequent stage of policy is to design markets that capture the values-"market creation"-ideally for the benefit of the many vulnerable communities that rely on the forests for their wall-being. These conclusions support the wider argument for using effective economic instruments to promote conservation of the remaining forests.

Peterson, G., D. Beard, et al. (2003). "Assessing future ecosystem services: a case study of the northern highlands lake district, Wisconsin." Conservation Ecology 7(3): 24.

The Northern Highlands Lake District of Wisconsin is in transition from a sparsely settled region to a more densely populated one. Expected changes offer benefits to northern Wisconsin residents but also threaten to degrade the ecological services they rely on. Because the future of this region is uncertain, it is difficult to make decisions that will avoid potential risks and take advantage of potential opportunities. We adopt a scenario planning approach to cope with this problem of prediction. We use an ecological assessment framework developed by the Millennium Ecosystem Assessment to determine key social and ecological driving forces in the Northern Highlands Lake District. From these, we describe three alternative scenarios to the year 2025 in which the projected use of ecological services is substantially different. The work reported in this paper demonstrates how scenarios can be developed for a region and provides a starting point for a participatory discussion of alternative futures for northern Wisconsin. Although the future is unknowable, we hope that the assessment process begun in this paper will help the people of the Northern Highlands Lake District choose the future path of their region.

Pimentel, D., C. Harvey, et al. (1995). "Environmental and economic costs of soil erosion and conservation benefits." Science 267: 1117-1123.

Soil erosion is a major environmental threat to the sustainability and productive capacity of agriculture. During the last 40 years, nearly one-third of the world's arable land has been lost by erosion and continues to be lost at a rate of more than 10 million hectares per year. With the addition of a quarter of a million people each day, the world population's food demand is increasing at a time when per capita food productivity is beginning to decline.

Pimm, S. (1997). "The value of everything." Nature 387: 231-232.

A commentary on Costanza et al's "The value of the world's ecosystem services and natural capital" in this same issue of Nature.

Pittman, J. and D. Batker (2006). Special benefit from the ecosystem services: Economic assessment of the King conservation district. Seattle, Earth Economics: 42.

This report analyzes the special benefits arising from ecosystems in the King Conservation District by using an economic methodology for valuation of the ecological goods and services. The King Conservation District Assessment Area has a large wealth of valuable natural capital assets in the form of thousands of acres of healthy ecosystems. These natural capital assets provide extensive value in terms of special benefits; these benefits are best understood as services provided by the ecosystems. The current assessment of $10 per acre (RCW 89.08.400) funds conservation programs and assistance activities provided by the KCD, WRIAs, and individual municipalities help maintain and improve the quality and economic value of ecosystem services. This funding creates a cost-effective conservation economy of scale that in turn provides value to landowners and the community.

This report shows that this Special Benefit Assessment is only a fraction of a percent of the total economic value provided to individual landowners and the greater community. Economic assessment of the economic value of ecosystems and conservation efforts is important for setting a scale to appropriate public and private funding; particularly since RCW 89.08.400 states that "the special assessments to be imposed on any land will not exceed the special benefit that the land receives or will receive from the activities of the conservation district." Scientists focused on environmental and ecological economics are only recently developing adequate assessment tools.

Prairie Conservation Forum (2006). Alberta prairie conservation action plan [2006-2010]. Lethbridge, Prairie Conservation Forum: 28.

The action plan is a report by the PCF to help aid in the protection of prairie and parkland ecosystems.

Prairie Farm Rehabilitation Administration (2000). Prairie agricultural landscapes: A land resource review. Agriculture and Agri-food Canada. Regina: 196.

This document provides a comprehensive assessment of the current state of the prairie landscape and current trends.

Prairie Habitat Joint Venture (2005). Introduction to ecological goods and services, Prairie Habitat Joint Venture: 2.

A brief, 2 page, brochure introducing the concept of ecological goods and services.

Pritchard, L., C. Folke, et al. (2000). "Valuation of ecosystem services in institutional context." Ecosystems 3: 36-40.

As long as we are forced to make choices, we are doing valuation. But different approaches to valuation are based on qualitatively different assumptions. For example, the economics approach to valuation is based on the ethical principle of consumer sovereignty, and it privileges the kinds of decisions individuals make in the marketplace. We accept the economics approach as a useful partial approach to decision making in relation to ecosystem services if one is interested in what people think about and want from services; if one believes that human preferences are the basis for the value of services; if one accepts the assumption that adding individual preferences reflects humanity's collective valuation of ecosystem services and life support; and if one assumes that marginal changes will only cause marginal consequences. The thesis of this article is that currently used modes of valuing ecosystem services do not take into account the inherent complexities and resulting uncertainties associated with dynamics of these coupled systems of people and nature. Ecosystem services are not a smooth, controllable function of human controls; rather, the nonlinearities and shifting relationships of these systems create changes that are inherently unpredictable. Human values and preferences are not static and pre-existent; rather, they are formed in interaction with nature and with society. Those types of uncertainties are difficult to capture with current modes of valuation. We end with some modest suggestions of institutional solutions to deal with those uncertainties. We begin with a weak typology of various goals of ecosystem valuation.

Proctor, W. (2001). Valuing Australia's ecosystem services using a deliberative multi-criteria approach. Frontiers 1 Conference: Fundamental Issues of Ecological Economics. Cambridge, European Society for Ecological Economics.

This paper describes one part of a major study being undertaken in Australia at present which involves valuing ecosystem services. The exercise is being based on all of the costs and benefits of these services (both monetary and intangible (in a case study region of Australia.

Proctor, W., S. Cork, et al. (2002). Assessing Ecosystem Services in Australia. 7th Biennial Conference of the International Society for Ecological Economics. Sousse, Tunisia, International Society for Ecological Economics.

Is a conference paper presented at the 7th Biennial Conference of the International Society for Ecological Economics on the Ecosystem Services Project in Australia.

Proctor, W. and M. Drechsler (2003). Deliberative multi-criteria evaluation: A case study of recreation and tourism options in Victoria Australia. Frontiers 2 Conference. Tenerife, European Society for Ecological Economics.

Multi-criteria evaluation is a well-tried and effective procedure for structuring and aiding complex decision-making processes — especially those involving environmental considerations. Formal deliberative processes have also been successful in aiding understanding and meeting consensus in complex and difficult decision problems which involve more than one decision-maker. Here, both approaches are combined to assist a group of natural resource managers decide on a suitable option for recreation and tourism activities in the upper Goulburn Broken Catchment of Victoria, Australia. This approach seeks to combine the advantages of Multi-criteria Evaluation providing structure and integration in complex decision problems with the advantages of deliberation and stakeholder interaction provided by a Citizens' Jury. First, a set of options and decision criteria were identified by the decision-makers. Next, the criteria were ranked to identify disparities in priorities for the decision-makers. A stakeholder jury process was then carried out with the decision-makers given the charge of coming to consensus on a set of weights for the criteria. Experts were called in to provide information on those criteria with wide disparities in priorities and a facilitated deliberative process was carried out including the requirement for decision-makers to support and defend their positions. A probabilistic Multi-criteria Evaluation software tool called ProDecX was used interactively to aid the decision-makers in their deliberations. It allows the simultaneous consideration of several stakeholders priorities and the assessment of the dissent within the group of decision-makers with respect to the criteria and options. In the process it helped to guide the group to the agreement on a single preferred option. An important outcome of the process was the discovery of some crucial aspects of the decision problem that require deeper understanding and assessment if that preferred strategy is to have the desired results. Some suggestions for improving the process were provided, but, in general, the stakeholder jury was regarded as a helpful and useful procedure by the decision-makers that aided them in their understanding of the issues of a complex decision-making problem.

Reeson, A. and J. Tisdell (2006). When good incentives go bad: An experimental study of institutions, motivations and crowding out: 23.

Many people voluntarily provide environmental goods and services. If supply is insufficient, a government may provide additional incentives. However, psychological studies indicate that incentives can crowd out the intrinsic motivations which prompt voluntary actions. We used experimental economics to examine these interactions, developing a scenario where people trade off private income against contributing to a public good. Our research found that formal institutions (regulation and competitive tender) crowded out voluntary contributions, with supply of public good increasing less than anticipated, or even decreasing. Crowding effects persisted even after an institution was revoked. Policy design should therefore tread carefully when incentives are combined with intrinsic motivations.

Reid, W., R. Costanza, et al. (2006). "Nature: the many benefits of ecosystem services." Nature 443: 749-750.

Commentaries on an article authored by Douglas J. McCauley entitled "Selling out on nature" (Nature 443, 27-28; 2006).

Revenga, C., J. Brunner, et al. (2000). Pilot analysis of global ecosystems: Freshwater systems. Washington, World Resources Institute: 78.

This study analyzes quantitative and qualitative information and develops selected indicators of the condition of the world's freshwater systems. The condition is defined as the current and future capacity of the systems to continue providing the full range of goods and services needed or valued by humans. Where available, we use global data sets to illustrate key indicators. In cases in which global data are not available, we use regional- and national-level information to illustrate important concepts, indicators, trends, and issues. Sometimes, local-level case studies have been used to illustrate trends that appear to be important but for which national or global data do not exist. Our analysis looks at measures that show the degree of human intervention in the hydrological cycle and what we know concerning three important goods and services provided by freshwater systems: water, food, and biodiversity. These goods and services were chosen partly on the advice of a wide range of freshwater experts and partly because of data availability.

Ronnback, P. (1999). "The ecological basis for economic value of seafood production supported by mangrove ecosystems." Ecological Economics 29: 235-252.

The undervaluation of natural products and ecological services generated by mangrove ecosystems is a major driving force behind the conversion of this system into alternative uses. This trend of undervaluation is partly due to the difficulty involved in placing a monetary value on all relevant factors, but lack of ecological knowledge and a holistic approach among those performing the evaluation may be even more important determinants. This article identifies and synthesizes ecological and biophysical links of mangroves that sustain capture fisheries and aquaculture production. Fish, crustacean and mollusc species associated with mangroves are presented and the ecology of their direct use of this system is reviewed. Through a coastal seascape perspective, biophysical interactions among mangroves, seagrass beds and coral reefs are illustrated. The life-support functions of mangrove ecosystems also set the framework for sustainable aquaculture in these environments. Estimates of the annual market value of capture fisheries supported by mangroves ranges from US$750 to 16 750 per hectare, which illustrates the potential support value of mangroves. The value of mangroves in seafood production would further increase by additional research on subsistence fisheries, biophysical support to other ecosystems, and the mechanisms which sustain aquaculture production.

Ropke, I. (2005). "Trends in the development of ecological economics from the late 1980s to the early 2000s." Ecological Economics 55: 262-290.

As the contributions to ecological economics are very diverse, recent years have seen some discussion on both how to delimit the field, and in which direction it should develop. The intention with this paper is to contribute to the discussion by outlining important trends in the development of the field from the late 1980s to the early 2000s. The study is inspired by other studies in the sociology and history of science, in particular by the theoretical framework regarding scientific fields as reputational organizations, which draws attention to both cognitive and social aspects of the formation of a field. The basis for the paper is a combination of literature studies, interviews with key researchers in the field, and participant observations. The paper outlines the characteristic cognitive features of ecological economics at the time of the birth of the field. It is then described how the development in ecological economics was influenced by broader social factors during the following years, and how the field was shaped by the inflow and outflow of different groups of researchers. The emergence of different research programmes is outlined, as is the organizational development. Finally, the characteristics of ecological economics are summarized and the future prospects are briefly assessed.

Roubik, D. (2002). "The value of bees to the coffee harvest." Nature 417: 708.

The self-pollinating African shrub Coffee-arabica, a pillar of tropical agriculture, was considered to gain nothing from insect pollinators1,2. But I show here that naturalized, non-native honeybees can augment pollination and boost crop yields by over 50%. These findings, together with world coffee-harvest statistics and results from field studies of organically shadegrown coffee, indicate that coffee plants would benefit from being grown in habitats that are suitable for sustaining valuable pollinators.

Rumsey, C., J. Ardron, et al. (2004). An ecosystem spatial analysis for Haida Gwaii, central coast, and north coast BC. C. I. Team. Victoria, Coast Information Team: 203.

This report presents a comprehensive ecosystem spatial analysis for the Haida Gwaii, Central Coast, and North Coast of British Columbia. The purpose of the ecosystem spatial analysis is to identify priority areas for biodiversity conservation and, to provide an information base and decision support for subsequent planning and management efforts designed to address four well-accepted goals of conservation: 1) represent ecosystems across a range of environmental gradients; 2) maintain viable populations of native species; 3) sustain ecological and evolutionary processes within a natural range of variability; and 4) build a conservation network that is resilient to environmental change. This approach does not explicitly examine the trade-offs between protected areas and management regimes applied to the intervening landbase or "matrix." The ESA team used the best available information for this assessment but recognizes that new and more comprehensive data will continually become available. Therefore, the ESA should be regarded as an initial step in an iterative assessment process.

Salzman, J., B. Thompson, et al. (2001). "Protecting ecosystem services: Science, economics and law." Stanford Environmental Law Journal 20: 309-332.

This issue of the Stanford Environmental Law Journal explores our current state of knowledge, presenting the results of interdisciplinary research conducted over the past three years on the legal, scientific and economic aspects of ecosystem services.

Sauer, A. (2002). The value of conservation easements: The importance of protecting nature and open space. West Hill Foundation for Nature, World Resources Institute: 30.

Regarding nature, we are a nation of contradiction, shortsightedness, and neglect. In Atlanta we create a world-class zoo to house some of the world's endangered species as we drive native species into extinction with housing developments, shopping malls, and office parks. We journey to Wyoming to experience the splendors of untamed wilderness while our desires for recreational homes fragment the land upon which wildlife depends. Our universities in Iowa are leaders in the study of sustainable agriculture, yet the rich soils on which we grow our food were created by prairie ecosystems that no longer exist. By ignoring the importance of nature in our economy, we are systematically degrading the base upon which all life depends. How long will critical natural areas last if they are deemed economically worthless? How long will it take before we recognize our dependence on nature for health, prosperity, and quality of life? Can we afford to find out?

Scarpa, R., S. Chilton, et al. (2000). "Valuing the recreational benefits from the creation of nature reserves in Irish forests." Ecological Economics 33: 237-250.

Data from a large-scale contingent valuation study are used to investigate the effects of forest attributes on willingness to pay for forest recreation in Ireland. In particular, the presence of a nature reserve in the forest is found to significantly increase the visitors' willingness to pay. A random utility model is used to estimate the welfare change associated with the creation of nature reserves in all the Irish forests currently without one. The yearly impact on visitors' economic welfare of new nature reserves approaches half a million pounds per annum, exclusive of non-recreational values.

Seidl, A. and A. Moraes (2000). "Global valuation of ecosystem services: application to the Pantanal da Nhecolandia, Brazil." Ecological Economics 33: 1-6.

In Costanza et al.'s famous Nature paper [Costanza, R., d'Arge, R, de Groot, R, Farber, S., Grasso, M., Hannon, B., et al. The value of the world's ecosystem services and natural capital. Nature 15 (387), 253–260.] A value for the world's ecosystem services is posited as a point of departure for further discussion. These calculations were re-estimated and qualitatively assessed in application to the Pantanal sub-region Nhecolandia. The original study was re-estimated to evaluate the sensitivity of the original study to more detailed and accurate data and to better understand the potential for the people of the Pantanal to benefit from environmental stewardship. Refocusing the analysis to the regional watershed level using locally derived data provided an opportunity to explore appropriate local policy alternatives and recognize regional biophysical heterogeneity which is largely impractical at the global, hemispheric or, perhaps, national scale. A value of more than US$15.5 billion, or US$5 million per resident was derived; an annual per hectare value of approximately 1:2 of Costanza et al.'s calculations. More biophysically diverse, but largely drier, regional conditions indicated by our data explain this discrepancy. Water supply and disturbance regulation contribute close to 2:3 of the total calculated value. Waste treatment, cultural value, and water regulation each contribute substantially (6–9%) to the total. Nutrient cycling, recreation, and habitat values play more minor roles (1.5–3%) in the total valuation. The concepts of imperfect substitutes and comparative advantage are applied within the broad category of natural capital in order to evaluate the potential of alternative economic development strategies for the region.

Shelton, D., S. Cork, et al. (2001). Application of an ecosystem services inventory approach to the Goulburn Broken Catchment. Third Australian Stream Management Conference. Brisbane, Cooperative Research Centre for Catchment Hydrology.

Rivers, streams and wetlands provide people with a wide range of benefits often referred to as "Ecosystem Services" (Cork et al. this volume). These services include maintenance of atmosphere and climates suitable for human life; filtration, purification and delivery of water; maintenance of soil fertility and structure; pollination of crops and other vegetation; control of the vast majority of potential pests, diseases and weeds; provision of genetic resources; production of goods like food and fibre; and provision of cultural, spiritual and intellectual values. The difficulty faced by natural resource managers is how do we prioritise and manage for the full range of benefits provided by ecosystems. This paper presents one method for identifying the full range of goods/products provided by ecosystems in a case study catchment (the Goulburn Broken in Northern Victoria), and a means of identifying, classifying and prioritising the role of ecosystem services in both transforming natural assets into those goods/products, or breaking down the by-products of those transformations.

Smith, K. (2006). "Public payments for environmental services from agriculture: Precedents and possibilities." American Journal of Agricultural Economics 88(5): 1167-1173.

This article briefly reviews the major characteristics of past and current public agrienvironmental payment programs, outlines problems with these precedents, especially those arising as scientific advancement allows finer designation of multiple environmental services, and proposes future program decision-making possibilities that would better approximate market-like equilibria for public good environmental services from agriculture.

Soderbaum, P. (1999). "Values, ideology and politics in ecological economics." Ecological Economics 28: 161-170.

Ecological economics is built on a value-commitment to study environmental issues and to contribute constructively to a more sustainable development path. However, many ecological economists still hesitate, it appears, to depart too much from other scholars by openly addressing issues of values and ideology. In this essay, the role of the scholar's orientation with respect to values and ideology is addressed. It is observed that not only scholars but also actors in society are guided by their 'ideological orientation'. This leads to the idea that some of the weaknesses of Economic Man and 'profit maximising firm' assumptions can be mitigated by introducing a Political Economic Person and a Political Economic Organisation.

Starrett, D. (1998). Valuing ecosystem services. Stanford, Stanford University: 14.

We develop the economist's concept of value as opportunity cost and discuss the ways in which decisions imply values through revealed preference. We distinguish between the ideas of incremental and total value and argue that only the former is of importance in practical decision-making. The relationship between price and value is articulated and related to the distinction between public and private goods. Finally, we enumerate the various ways economists use to determine the value of ecosystem services-these include use of prices, methods of revealed preference, voting schemes and contingent value.

Starrett, D. (2000). "Shadow pricing in economics." Ecosystems 3: 16-20.

Starrett provides a discussion of how shadow pricing applies to goods and services for which there are no markets.

Sutton, P. (2003). "An empirical environmental sustainability index derived solely from nighttime satellite imagery and ecosystem service valuation." Population and Environment 24(4): 293-311.

This paper describes a crude yet simple Environmental Sustainability Index (ESI) derived solely from the ratio of two classified satellite images with global coverage. An ESI is calculated for each nation of the world by dividing the amount of light energy emitted by that nation as measured by a nighttime satellite image into the total value of that nation's ecosystem services as measured by a land-cover dataset and ecosystem service values estimated by Costanza et al. 1997.

Sutton, P. and R. Costanza (2002). "Global estimates of market and non-market values derived from nighttime satellite imagery, land cover, and ecosystem service valuation." Ecological Economics 41: 509-527.

We estimated global marketed and non-marketed economic value from two classified satellite images with global coverage at 1 km2 resolution. GDP (a measure of marketed economic output) is correlated with the amount of light energy (LE) emitted by that nation as measured by nighttime satellite images. LE emitted is more spatially explicit than whole country GDP, may (for some nations or regions) be a more accurate indicator of economic activity than GDP itself, can be directly observed, and can be easily updated on an annual basis. As far as we know, this is the first global map of estimated economic activity produced at this high spatial resolution (1 km2). Ecosystem services product (ESP) is an important type of non-marketed value. ESP at 1 km2 resolution was estimated using the IGBP land-cover dataset and unit ecosystem service values estimated by Costanza et al. The sum of these two (GDP+ESP)=SEP is a measure of the subtotal ecological–economic product (marketed plus a significant portion of the non-marketed). The ratio: (ESP/SEP)×100=%ESP is a measure of proportion of the SEP from ecosystem services. Both SEP and %ESP were calculated and mapped for each 1 km2 pixel on the earth's surface, and aggregated by country. Results show the detailed spatial patterns of GDP, ESP, and SEP. Globally, while GDP is concentrated in the northern industrialized countries, ESP is concentrated in tropical regions and in wetlands and other coastal systems. %ESP ranges from 1% for Belgium and Luxembourg to 3% for the Netherlands, 18% for India, 22% for the United States, 49% for Costa Rica, 57% for Chile, 73% for Brazil, and 92% for Russia. While GDP per capita has the usual northern industrialized countries at the top of the list, SEP per capita shows a quite different picture, with a mixture of countries with either high GDP/capita, high ESP/capita, or a combination near the top of the list. Finally, we compare our results with two other indices: (1) The 2001 Environmental Sustainability Index (ESI) derived as an initiative of the Global Leaders of Tomorrow Environment Task Force, World Economic Forum, and (2) Ecological Footprints of Nations: How much Nature do they use? How much Nature do they have? developed by Mathis Wackernagel and others. While both of these indices purport to measure sustainability, the ESI is actually mainly a measure of economic activity (and is correlated with GDP), while the Eco-Footprint index is a measure of environmental impact. The related eco-deficit (national ecological capacity minus national footprint) correlates well with %ESP.

Sweetgrass Consulting Ltd. (1997). Environmentally significant areas of Alberta. Calgary: 586.

The primary purpose of this ESA study was to evaluate and provide an overview of all ESA inventories completed to date in Alberta and to determine which areas were of provincial, national or international significance. An analysis of Level 1 Natural History Theme occurrence in each of the ESAs was a significant component of this project. From an analysis of aerial photographs and dominant surficial themes identified from the literature, surficial landform units were mapped and the percentage occurrence of the 20 Level 1 Natural History Themes defined by Alberta Parks Services was determined for every surficial landform unit within each ESA.

Swinton, F., F. Lupi, et al. (2006). "Ecosystem services from agriculture: Looking beyond the usual suspects." American Journal of Agricultural Economics 88(5): 1160-1166.

Compared to more natural ecosystems agriculture and forestry have much readier potential to expand their supply of currently nonmarketed ES for three reasons: (1) much is known about biophysical input/output relationships in the system, (2) there exist precedents for economic incentives that could induce greater ES supply, and (3) the past performance of agriculture suggests strong capability to supply goods and services in response to attractive incentives. This paper expands on these themes by exploring the history of public awareness and reaction to ES linked to agriculture, some precedents for inducing farmers to supply a different product mix, the existing research base on agriculture as viewed from an ES perspective, and research needs in order to augment the provision of currently nonmarketed ES from agricultural lands.

The Canada West Foundation (2005). The next big idea: Investing in our natural capital. Dialogues. Winter 2005: 36.

This is the first edition of dialogues a periodical produced by the CWF. In this issue, the theme of natural capital is discussed from a broad range of perspectives. Articles include: Having our cake and eating it too:

Investing in natural capital; Measuring success: Putting our environmental house in order; Protecting natural capital in British Columbia: The role of land and resource management planning; Shifting from a culture of production to a culture of marketing: Alberta's primary agricultural production sector is in crisis; Every drop counts: A new way of managing water in the West; Are we penny wise but pound foolish? Knowledge of our natural capital; Shell's commitment to the Waterton-Castle Region; Yellowstone to Yukon: Applying continental conservation in Alberta; Good neighbours; Calgary at a crossroads; Science-based landscape management; Seeing green: integrating nature and the built environment; Doing what comes naturally.

U.S. Department of Agriculture (2006). Valuing ecosystem services: Capturing the true value of nature's capital. F. Service. Washington, U.S. Department of Agriculture: 2.

The United States Department of Agriculture provides an introduction to valuing ecosystem services.

United Nations, European Commission, et al. (2003). Integrated environmental and economic accounting 2003 Studies in Methods: Handbook of National Accounting. E. C. United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development, World Bank: 598.

The handbook provides a common framework for economic and environmental information, permitting a consistent analysis of the contribution of the environment to the economy and of the impact of the economy on the environment. It is intended to meet the needs of policy makers by providing indicators and descriptive statistics to monitor the interaction between the economy and the environment as well as serving as a tool for strategic planning and policy analysis to identify more sustainable development paths. The handbook covers complex and diverse topics some of which are still subject to debate. Whenever possible, it reports best practices, and where a variety of approaches exists, their advantages and disadvantages are presented. Even though a single recommendation could not always be given, the handbook represents a major step towards harmonized concepts and definitions, and will provide the basis for the further development of standards.

Vemuri, A. and R. Costanza (2006). "The role of human, social, built, and natural capital in explaining life satisfaction at the country level: Toward a National Well-Being Index (NWI)." Ecological Economics 58: 119-133.

This paper investigates the contributions to life satisfaction of four basic types of capital: human, social, built, and natural. Life satisfaction data were available for respondents from fifty-seven countries from the World Values Survey over the decade of the 1990s. Data on proxies for human, social, built, and natural capital were available for 171 countries, using data from the 1998 United Nations Human Development Report, News of the Century: Press Freedom 1999 and Global estimates of market and non-market values derived from nighttime satellite imagery, land cover, and ecosystem service valuation. Regression models show that both the UN Human Development Index (HDI — which includes proxies for both built and human capital) and an index of the value of ecosystem services per km2 (as a proxy for natural capital) are important factors in explaining life satisfaction at the country level and together can explain 72% of the variation in life satisfaction. We did not find a proxy for social capital that was a significant predictor in the regression models. This was due to the inadequacy of available proxy variables for social capital at the national scale and intercorrelation with other variables. We discuss data limitations and a range of other problems with the existing limited data along with methods to overcome some of these limitations to improve future analyses. We propose a National Well-Being Index (NWI) based on our findings and describe a path to improve it over time.

Villa, F. and H. McLeod (2002). "Environmental vulnerability indicators for environmental planning and decision-making: guidelines and applications." Environmental Management 29(3): 335-348.

This paper discusses frameworks for a "least disappointing," approximate quantification of environmental vulnerability. After a review of recent research and recent attempts to quantify environmental vulnerability, we discuss models and theoretical frameworks for obtaining an approximate, standardizable vulnerability indicator of minimal subjectivity and maximum generality. We also discuss issues of empirical testing and comparability between indicators developed for different environments. To assess the state of the art, we describe an independent ongoing project developed in the South Pacific area and aimed to the comparative evaluation of the vulnerability of arbitrary countries.

Villa, F., M. Wilson, et al. (2002). "Designing an integrated knowledge base to support ecosystem services valuation." Ecological Economics 41: 445-456.

Quantifying the value of ecosystem services is important for the social recognition and acceptance of ecosystem management across multiple geographic scales. Yet, the data required to perform such quantifications and the dynamic models that allow the projection of policy changes into the future are currently scattered, incomplete, and difficult to use. We describe the design of the Ecosystem Services Database (ESD), an integrated,

web-accessible knowledge base that links a relational database for temporally and spatially explicit data to dynamic simulation models. The ESD architecture supports unit standardization, scale translation in space and time, and statistical analysis. Process-based dynamic models and valuation methods can be run by end users either through a web-based simulation engine or on their own computers by means of open-source software. The knowledge base will serve as: (1) a communication tool for use by researchers in several fields; (2) an analytical tool for meta-analysis, synthesis, and prediction; (3) an educational tool to disseminate knowledge on ecosystem services and their valuation; (4) a collaborative tool for institutions involved in different aspects of ecosystem service valuation; and (5) a prototype for linking databases and dynamic models.

Westman, W. (1977). "How much are nature's services worth?" Science 197: 960-964.

One of the first to write about the value of ecosystem goods and services, Westman noted that "measuring the social benefits of ecosystem function is both controversial and illuminating".

White, R., S. Murray, et al. (2000). Pilot analysis of global ecosystems: Grassland ecosystems. Washington, World Resources Institute: 81.

The Grassland Ecosystems report focuses on a selected set of grassland goods and services: food, forage and livestock, biodiversity, carbon storage, and tourism and recreation. Each good or service is discussed in terms of its current status and modifications that have altered its condition such as cultivation, urbanization, fire, livestock grazing, and introduction of invasive species. Results show that although the major goods and services provided by grasslands are in good to fair condition, the capacity for grassland ecosystems to continue to provide these goods and services is declining.

White, R. and J. Nackoney (2003). Drylands, people, and ecosystem goods and services: A web-based geospatial analysis. Washington, World Resources Institute: 40.

The following report has been prepared to expand the ecosystems addressed in PAGE by presenting information on a global scale about the goods and services provided by drylands. In addition, this report provides baseline information for ongoing and future assessments of drylands, including the Millennium Ecosystem Assessment (MA) (www.millenniumassessment.org) and the Land Degradation Assessment in Drylands (LADA) (www.fao.org/ag/agl/agll/lada/). Further, this report can provide baseline information and ideas for developing dryland indicators for the United Nation's Convention to Combat Desertification (UNCCD) through the Committee on Science and Technology and potential requests to parties for the adoption of an ecosystem approach in their national action planning process. This web-based analysis takes advantage of the power of geospatial technologies to examine the world's drylands. We consider drylands from the perspective of human livelihoods, examining how these livelihoods are integrated with dryland ecosystem goods and services. We focus on a selected set of dryland goods and services: forage and livestock; food production; biodiversity conservation; freshwater; carbon storage; energy production; and tourism and recreation. The final two sections examine drylands and trade and drylands and the impacts of human activities. Each subject area is generally presented with a brief overview, map, map description, and list of sources. Links are provided to associated data tables and text boxes. All maps are shown in Geographic projection.

White, R., D. Tunstall, et al. (2002). An ecosystem approach to drylands: Building support for new development policies. Washington, World Resources Institute: 14.

Examines current issues surrounding dryland management policies and the livelihoods of people who live in dryland areas. This policy brief examines current issues surrounding dryland management policies and the livelihoods of people who live in dryland areas. The report presents the ecosystem goods and services approach as a powerful tool to help increase support for improving the livelihoods of people living in drylands.

Whitten, S. and E. Bennett (n.d). A bio-economic model of wetland protection on private lands. National Wetlands Research and Development Program., Environment Australia and Land and Water Australia: 30.

Wetland ecosystems on privately owned farms - such as those on the Murrumbidgee River Floodplain in the state of New South Wales, Australia - provide a mix of potentially valuable outputs to their owners and the wider community. The mix of values generated is dependent on the biophysical status of the wetlands, which in-turn is dependent on the land management in and around these multiple-output ecosystems. Despite the range of private and public values generated, management decisions are based primarily on the private values that landowners receive. These private land management decisions also affect social values. Hence, there is potentially a demand for public policy to influence decisions based on the social values wetlands generate. This paper is predicated on the principle that good policy is reliant on information about wetland values. We present an integrated bio-economic model of wetland management that incorporates the biological and economic impacts at a landscape scale. The model reflects the multiple private and social values generated by wetlands and the dynamic

nature of the trade-offs between these values. A number of broad policy conclusions for wetland management in Australia are generated from the outputs of the bio-economic model.

Whitten, S. and E. Bennett (n.d). Economics for natural resources management: Bio-economic modelling, policy threshold analysis and transaction costs. National Wetlands Research and Development Program, Environment Australia and Land and Water Australia: 32.

Environmental policy has assumed a high profile in Australia with policies being recently developed to target aspects of land degradation, forest management and climate change, among others. These policies are often based on relatively little information about the likely benefits to be generated, costs borne by stakeholders, or, the relative transaction costs of policy options to stakeholders and government. In this paper we address these issues via two case studies of wetland policy. A bio-economic model of wetlands on private lands informs the scale of the policy response. The concept of policy threshold analysis is then developed as a filter to take into account transaction costs in an information poor environment. The transaction costs incurred include policy development, implementation, and, resource reallocation. The degree of irreversibility and the notion of environmental impact thresholds also affect the choice and timing of alternative policy options. Timing of policy is therefore a function of quasi-option values – the value of postponing a decision to obtain more information.

Whitten, S. and E. Bennett (n.d). Social values of privately owned wetland resources. Canberra, CSIRO Sustainable Ecosystems: 13.

Farmers prize the relatively fertile valley floors and flood plains across Australia and elsewhere. But important wetlands are often located in these areas. This is the case in the Upper South East of South Australia and on the Murrumbidgee River Floodplain in NSW. The agricultural production values desired by farmers potentially conflict with the wetland conservation values enjoyed by both farmers and the wider community. These include recreational uses and biodiversity protection. A demand for changes to wetland policy may reflect conflicts between decisions made by farmers that enhance their private values and those necessary to maintain the social values of wetlands. However, good policy is reliant on information about both the private and social values generated by wetlands. In this paper we report the use of a choice modelling survey to estimate the social values generated by an array of alternative wetland management options. The results indicate that policies resulting in changes to wetland management could increase the net social benefits generated by wetlands in these regions.

Whitten, S., J. Bennett, et al. (2002). Incentive measures for conserving freshwater ecosystems: Review and recommendations for Australian policy makers. National River Health Program, Environment Australia.

In this report 27 incentive measures for promoting the conservation of freshwater ecosystems by private landholders are reviewed. Many of these measures are currently available in Australia while others, that are in use in other countries, are only now beginning to be considered here. Each incentive measure is considered against the following criteria; ecological efficiency, economic efficiency, social impact, flexibility, accountability and potential for community involvement, and for each incentive option recommendations have been formulated that are designed to offer guidance to policy makers at all levels of Government (as appropriate) for seeing these measures made more affective. Short case studies relating to some of the incentive measure are also provided. The overall conclusion of this report is that while Australia has a considerable range of such incentive measures operating today, many are being applied in a piece-meal or ad hoc fashion. Further, many of the incentives are being used in other areas of natural resource management, such as vegetation management, however these have not been targeted specifically at wetland conservation. There is clearly potential, and a mandate, for the Commonwealth Government to take more of a leadership role in seeing national application of incentive measures for conserving freshwater ecosystems by State/Territory and local governments.

Whitten, S., J. Salzman, et al. (2003). Markets for ecosystem services: applying the concepts. 47th Annual Conference of the Australian Agricultural and Resource Economics Society. Fremantle.

In recent times, use of market-based instruments to facilitate enhanced protection or production of ecosystem services has achieved a high public profile. However, much work remains to apply these tools in practice. Particular issues include definition and measurement of ecosystem services, development of institutions and mechanisms to facilitate trade and integration of these instruments into the broader natural resource management agenda and toolbox. In this paper these issues are explored with respect to pilot markets for ecosystem services in three case study catchments. Emphasis is placed on pilot selection rationale and identification of key facilitative mechanisms and institutions.

Whitten, S., M. van Bueren, et al. (2003). An overview of market-based instruments and environmental policy in Australia. 6th Annual National AARES Symposium. Canberra: 18.

Market-based instruments for environmental management are relatively new mechanisms in both an Australian and international policy context. However, they are increasingly being considered for the management of natural resources and the environment. This is particularly so where regulatory approaches have failed to arrest on-going degradation or where the cost of traditional policy tools is proving prohibitive to government or society in general. In this context we address four issues in this paper. 1. What is the historical policy context that has led to the emergence of market-based policy instruments in Australia? 2. What are market-based instruments and why are they useful as a policy tool? More specifically, what theoretical and practical advantages do they offer over more traditional instruments? 3. What schemes are in operation in Australia and how successful have they been? and, 4. Are there any lessons to date for their future application?

Whitten, S. and M. Young (2003). Market-based tools for environmental management: where do they fit and where to next? 6th Annual National AARES Symposium. Canberra: 11.

Eighteen papers are presented in this volume relating to MBI theory, design and experience. In this paper we synthesise some of the key lessons that emerge from these papers and the discussion at the symposium in which they were presented. A key conclusion is that MBIs offer both great promises, but also potential pitfalls. Their promise can be achieved while avoiding many of the pitfalls by paying careful attention to MBI design focusing on: property rights; risk and who bears it; flexibility of action; equity implications; and, the evolution of instruments through time. Careful design is no panacea however, as there remain a number of areas of conceptual or practical design that are yet to be sufficiently addressed to provide guidance.

Willis, K. and J. Corkindale, Eds. (1995). Environmental valuation: New perspectives Wallingford, CAB International.

The measurement of environmental costs and benefits is an increasingly important aspect of the appraisal of policies and projects. Yet questions of how such appraisals can take account of environmental impacts, how non-marketed environmental effects can be valued in monetary terms, and how these values should be used in the development of policy remain controversial. This volume consists of papers developed from a conference sponsored by the Department of the Environment in the U.K. Six key topics are addressed: cost-benefit analysis; the contrasting approaches of economists and ecologists; the pros and cons of alternative valuation methods; contingent valuation; the transferability of environmental benefit estimates; and the establishment of research priorities. The book provides valuable new insights for advanced students and policy-makers in environmental economics and related disciplines.

Wilson, M. and R. Howarth (2002). "Discourse-based valuation of ecosystem services: establishing fair outcomes through group deliberation." Ecological Economics 41: 431-443.

Discourse-based methods involving small groups of citizens have yet to be thoroughly engaged in the practice of ecosystem valuation. This remains true despite the fact that many ecosystem goods and services—such as clean air, biodiversity, and unpolluted lakes and rivers—are considered to be public goods. The conventional application of ecosystem valuation relies heavily on methodologies such as contingent valuation, in which individuals are asked to express the value they attach to ecosystem goods and services in social isolation. The difference between the public nature of ecosystem services and their valuation through individual expression has thus recently led to calls for more deliberative forms of environmental valuation. Because the allocation of ecosystem services directly affects many people and raises normative questions about social equity, it is argued that carefully designed discursive methods will help ensure the achievement of social equity goals. In this paper, we examine the theoretical and normative assumptions that rest beneath the proposed turn towards discourse-based methods, and identify procedures for testing their application in the field.

Winkler, R. (2006). "Valuation of ecosystem goods and services Part 2: Implications of unpredictable novel change." Ecological Economics 59: 94-105.

This is the second part of a two-part paper which offers a new approach to the valuation of ecosystem goods and services. In the first part a simple pre-industrial model was introduced to show how the interdependencies between the three subsystems, society, economy and nature, influence values, and how values change over time. In this second part the assumption of perfect foresight is dropped. I argue that due to novelty and complexity ex ante unpredictable change occurs within the three subsystems society, economy and nature. Again the simple pre-industrial model, which was introduced in part 1, serves as a simple paradigm to show how unpredictable novel change limits the possibility to derive accurate estimates of values.

Winkler, R. (2006). "Valuation of ecosystem goods and services: Part 1: An integrated dynamic approach." Ecological Economics 59(1): 82-93.

This is the first part of a two-part paper which offers a new approach to the valuation of ecosystem goods and services. The existing literature on environmental valuation is based on two distinct foundations. The ecological valuation methods derive values by a cost of production approach. Their common characteristic is the neglect of consumer preferences. The economic valuation methods focus on the exchange value of ecosystem services. Their common characteristic is that they are finally based on consumer preferences, and do not adequately take account of the complex internal structure of ecosystems. As the existing methods for the valuation of ecosystem services emphasize either the economic system or the ecosystem, the main objective of part 1 is to provide the conceptual foundations for a new method of valuation of ecosystem services, which deals simultaneously with the ecosystem, the economic system and society in a balanced way. Within a simple pre-industrial model it is shown how the interdependencies between the three subsystems influence values, and how values change over time.

Wolcott, R. (2006). "Prospects for an ecosystem services in the future agricultural economy: Reflections of a policy hand." American Journal of Agricultural Economics 88(5): 1181-1183.

The design of this paper is to provide an important frame for consideration of the policy analytic prospects and potholes ahead. They also serve as catalysts for enlightened, strategic inquiry.

Wood, S., K. Sebastian, et al. (2000). Pilot analysis of global ecosystems: Agroecosystems Washington, World Resources Institute: 125.

The Agroecosystems study analyzed qualitative and quantitative indicators of the condition of the world's agroecosystems in terms of the delivery of a number of key goods and services valued by society. These goods and services include food, feed and fiber; water services; biodiversity; and carbon storage. The study also attempted to assess the state of the underlying soil resource conditions, both as a determinant of agroecosystem capacity to produce goods and services and as a consequence of agroecosystem management practices.

Worbets, B. and L. Berdahl (2003). Western Canada's natural capital: Toward a new public policy framework. Natural Capital Project. Calgary, The Canada West Foundation: 36.

The objective of Western Canada's Natural Capital is to draw attention to the importance of natural capital for public policy, and to argue for the greater recognition of natural capital within public policy discussions in the West. The long-term prosperity of the West depends on finding the appropriate public policy balance among produced, human and natural capital. Western Canada's Natural Capital is designed to create a new public policy language for environmental protection. Over the past decade, the politics of environmentalism have been polarized, pitting environmental protection against economic development. In the context of the West, however, this polarization makes little sense given the economic value of natural capital. Hence the need to find a public policy framework built around the notion of environmental prosperity, a framework that recognizes that sustaining natural capital is an essential precondition for economic prosperity. Western Canada's Natural Capital recognizes that the connections western Canadians have with natural capital are not restricted to wild landscapes, that they extend to the urban environments within which most western Canadians live, and to the working environments that reflect both our economic base and heritage. Public opinion data presented in Western Canada's Natural Capital demonstrate that western Canadians place a high priority on environmental protection. They also show that western Canadians reject the often assumed tension between economic prosperity and environmental protection; instead, the two are seen as complementary. The report does not make specific public policy recommendations. Rather, its goal is to open a new dialogue on public policy, and to find a language that brings the preservation of natural landscapes to the heart of public policy debate within the West. Simply put, western Canada's prosperity depends on our ability to balance the long-term growth of the economy with the urban, working and wild landscapes we all cherish.

World Resources Institute (2000). A guide to world resources 2000–2001 - People and ecosystems: the fraying web of life. Washington, World Resources Institute.

The goals of World Resources 2000–2001 are twofold. The first goal is to report on the condition of Earth's ecosystems at the dawn of the new millennium—a time when humans exert a dominant and growing influence on these systems. To focus attention on what is known—and what more we vitally need to know—World Resources 2000–2001 presents the results of a first-of-its-kind Pilot Analysis of Global Ecosystems, undertaken in 1999. This analysis is unique in that it gauges the condition of ecosystems by examining the goods and services they currently produce—food, fiber, clean water, biodiversity, carbon storage, recreation, and others—and their capacity to continue producing them in the future. Although the gaps in the data limit the thoroughness of the analysis, it is as comprehensive as possible in its coverage. The results offer a sobering glimpse at how we have altered ecosystems to our purposes, increasing both benefits and vulnerability. A second and equally important goal of World Resources 2000–2001 is to motivate nations, local communities, and individuals to adopt an ecosystem-oriented approach to managing the environment.

World Resources Institute (n.d). What is the World Resources Institute doing to address the Millennium Ecosystem Assessment findings? Millennium Ecosystem Assessment. Washington, World Resources Institute.

This is a brief unpublished document created by the WRI and provided to IEL that describes what the WRI is doing to address the Millennium Ecosystem Assessment findings.

World Resources Program (2001). Valuing ecosystem services. World Resources Institute: 1-4.

A short brief on ecosystem valuation that illustrates the value of nature's goods and services using Costanza et al's 1997 numbers.

World Wildlife Fund (2003). From goodwill to payments for environmental services: a survey of financing options for sustainable natural resource management in developing countries. Macroeconomics for Sustainable Development Program Office. Washington, World Wildlife Fund: 148.

The World Wildlife Fund has produced a document that considers mechanisms for financing sustainable natural resource management such as markets for ecosystem services and payments for ecosystem services.

Wossink, A. and S. Swinton (2006). Valuation with supply tools: Willingness–to-accept-payment for ecosystem services from agriculture.

This paper highlights how farmers' willingness to accept payment for provision of ecosystem services (ES) is influenced by whether or not the ES are produced jointly with agricultural products. When marketed products and ES share some production inputs the production relationships between the two may be complementary, competitive or substitute. Using a cost minimization framework, it is shown how complementary relationships lead to costless voluntary provision of ES (typically the case for ES that are supportive of provisioning ES for marketed farm products), as well as how competitive production relationships lead to provision of ES at lower cost than when ES are direct substitutes for farm products or are produced outside of agriculture. The paper closes by showing how willingness to accept (WTA) payment for ES that are complementary-competitive are less than or equal to WTA for the same ES produced in substitute or independent production relationships.

Wylynko, D., (Ed.) (1999). Prairie wetlands and carbon sequestration: Assessing sinks under the Kyoto Protocol. Winnipeg, International Institute for Sustainable Development, Wetlands International, and Ducks Unlimited Inc.: 52.

This summary paper addresses the major issues concerning prairie and parkland wetlands as carbon sinks and presents the background to the Kyoto Protocol and the provisions for carbon sinks within the Protocol. It discusses the possible inclusion of wetlands as sinks and policy advancements since Kyoto. The paper describes human settlement and activities that have an impact on prairie wetlands, and gives an overview of carbon sequestration potential in wetlands and related upland areas in the Central Plains, including techniques available for measuring carbon cycling. A final section describes scientific and policy issues that must be taken into account in any effort to see wetlands included in the Kyoto Protocol. This document does not propose policy options for achieving wetland creation and restoration, but it acknowledges that such policies are critical to wetland conservation initiatives.